Slutrapport til Arbejdsmiljøforskningsfonden:

Helbredskonsekvenser af lysmiljøet ved indendørs- og natarbejde, Lux@r projektet

Henrik A. Kolstad, Stine Daugaard, Åse Marie Hansen, Jens Peter Bonde, Jens Christoffersen, Jakob Markvart og Anne Helene Garde

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Forfattere: Henrik A. Kolstad, Stine Daugaard, Åse Marie Hansen, Jens Peter Bonde, Jens Christoffersen, Jakob Markvart og Anne Helene Garde
Institution: Arbejdsmedicinsk Klinik, Dansk Ramazzini Center, Aarhus Universitetshospital
Udgiver: Arbejdsmedicinsk Klinik, Dansk Ramazzini Center, Aarhus Universitetshospital
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Arbejdsmedicinsk Klinik, Dansk Ramazzini Center
Aarhus Universitetshospital
Nørrebrogade 44, bygning 2C
8000 Aarhus C
Tlf.: 7846 4290
Fax: 7846 4260
E-post: auharb@rm.dk
http://www.auh.dk/om+auh/afdelinger/arbejdsmedicinsk+klinik
http://ramazzini.dk/index.php/da/

Indhold

Forord

Arbejdsmiljøforskningsfonden støttede gennemførelsen af LUX@R-projektet, som har løbet fra den 1.1 2011 til 31.12. 2016. Denne rapport giver et overblik over de resultater, som er opnået.

Projektgruppen har bestået af Anne Helene Garde, Det Nationale Forskningscenter for Arbejdsmiljø (NFA), Åse Marie Hansen, NFA og Københavns Universitet, Jens Peter Bonde, Bispebjerg Universitetshospital, Jens Christoffersen, Velux A/S, Jakob Markvart, Aalborg Universitet, og Henrik A. Kolstad, Aarhus Universitetshospital (AUH).

Morten Frydenberg, Aarhus Universitet (AU), Peer Christiansen, AUH, og Johnni Hansen, Kræftens Bekæmpelse har bidraget til analyser af natarbejde og risiko for brystkræft baseret på analyser af Dansk Arbejdstids Database (DAD). Vivi Schlünssen, AU og NFA og Debra Skene, University of Surrey, United Kingdom, har bidaget til analyser af natarbejde og melatonin og lysmiljøet. Jesper Medom Vestergaard, AUH, har stået for oparbejdningen af database over målinger udført i feltstudiet af natarbejdere, udendørsarbejdere og indendørs dagarbejdere.

Helene Tilma Vistisen har været PhD studerende og stået for analyser af natarbejde og risiko for brystkræft. Stine Daugaard Pedersen har været PhD studerende finansieret med et kandidatstipendium fra af Aarhus Universitet, og har stået for analyser af arbejdstid, lyseksponering og melatonin. Anne Helene Garde, Peer Christiansen og Henrik Kolstad var vejledere for Helene Tilma Vistisen. Anne Helene Garde, Jens Peter Bonde og Henrik Kolstad var vejledere for Stine Daugaard. Ida Katrine Thomsen og Anna Huus Eriksson har analyseret betydningen af lyseksponering og henholdsvis depressive symptomer og søvn som led i deres studier på Aarhus Universitet under vejledning af Stine Daugaard og Henrik Kolstad.

Anja Jørgensen, Louise Brus Hesselvang, Anne Abildtrup, Inge Christensen, Dorrit Meincke og Ulla Tegner stod for indsamlingen af data i feltstudiet.

Vi retter en varm tak til alle deltagende virksomheder og alle ansatte, som har deltaget i denne undersøgelse, Arbejdsmiljøforskningsfonden og Health, Aarhus Universitet, som gjorde undersøgelsen mulig.

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Stine Daugaard, Anne Helene Garde, Åse Marie Hansen, Jens Peter Bonde, Jens Christoffersen, Jakob Markvart og Henrik A. Kolstad

Resumé

Det overordnede formål med LUX@R-projektet var at undersøge om lysmiljøet ved indendørsarbejde og natarbejde har helbredsmæssige konsekvenser:

1) Om udsættelse for lave niveauer af lys om dagen ved indendørsarbejde giver forøget risiko for depression, søvnforstyrrelser og almensymptomer.

2) Om udsættelse for høje niveauer af lys om natten ved natarbejde giver forøget risiko for brystkræft.

3) Om udsættelse for lave niveauer af lys ved indendørsarbejde og høje niveauer af lys ved natarbejde ændrer den biologiske døgnrytme.

Vi fandt ingen forøget risiko for brystkræft ved nyligt natarbejde blandt af 155.569 kvinder ansat i danske regioner mellem 2007 og 2012. Dette fund og den metodemæssige tilgang har videnskabelig nyhedsværdi. I 2007 klassificerede the International Agency of Cancer (IARC) natarbejde som sandsynligt kræftfremkaldende for mennesker baseret bl.a. på epidemiologiske studier. Disse undersøgelser var dog behæftet med større metodemæssige svagheder, primært informationsbias relateret til selvrapporterede eksponeringsoplysninger. Det tog vi højde for ved at anvende præcise dag-til-dag arbejdstidsoplysninger fra lønregistre, som vi koblede bl.a. med cancerregistre og en række andre offentlige registre. Undersøgelsen var dog begrænset af, at vi ikke havde oplysninger om, og dermed ikke kunne vurdere evt. risiko af, længere tids natarbejde eller det at have haft natarbejde for mere end 5 år siden.

Vi har undersøgt om natarbejde nedsætter melatonin koncentrationen (døgnrytme hormon) i spyt på dage med natarbejde og på fridage blandt 341 natarbejdere, udendørsarbejdere og indendørs dagarbejdere. Alle deltagere blev fulgt tæt gennem en uge med kontinuerlig målinger af lysniveauer, spytprøver, som blev analyseret for melatonin, og dagbogsregistreringer af bl.a. arbejdstider. Vi analyserede om udsættelse for lys medierer sammenhængen mellem natarbejde og melatonin koncentrationen i spyt. Dette har ikke tidligere været undersøgt blandt natarbejdere, når de udfører deres sædvanlige arbejde. Analyserne viste at melatonin koncentrationen var lavere på dage med natarbejde end på dage med dagarbejde og at denne forskel blev delvist medieret af lysniveauet om natten, men det var få natarbejdere, som var udsat for høje lysniveauer, når de var på nattevagt. Vi fandt ingen forskel i melatonin niveaer mellem dag og natarbejdere på fridage. Vi kunne således konkludere at natarbejde har en forbigående effekt på melatonin, som delvist medieres af lys, og at de fleste natarbejdere i dette studie var udsat for lave lysniveauer, når de var på vagt.

I denne gruppe af natarbejdere, udendørs dagarbejdere og indendørs dagarbejdere har vi også undersøgt om forekomsten af depressive symptomer og søvnlængde hænger sammen med lysniveauet. Analyserne dannede grundlag for en master afhandling ved den Sundhedsfaglige Kandidatuddannelse og en bachelor afhandling i

Public Health Sciences, begge ved Health, Aarhus Universitet, men har endnu ikke været gennem fagfællesbedømmelse i et videnskabeligt tidsskrift.

Vi har kortlagt lysniveauerne på arbejdsdage og fridage for 535 natarbejdere, udendørs dagarbejdere og indendørs dagarbejdere. Resultaterne har været fremlagt ved videnskabelige konferencer, et manuskript er under fagfællebedømmelse ved et internationalt tidsskrift og resultaterne vil danne grundlag for fremtidige analyser af depression og andre helbredseffekter, hvor lys kan være en risikofaktor, i hele den arbejdende danske befolkning.

Vores resultater vedrørende nyligt natarbejde og brystkræft er beroligende og vil indgå i den samlede vurdering af om natarbejde skal klassificeres og reguleres som kræftfremkaldende. Analyserne af melatonin tyder ikke på en vedvarende effekt natarbejde og dette understøtter konklusionen på analyserne af brystkræft. Dette vil få indflydelse på fremtidige anbefalinger om tilrettelæggelse af natarbejde, som kan få betydning for de mange, som ikke kan undgå at arbejde om natten. Fundene vedrørende lyseksponeringsniveauer er bl.a. relevant for de mange, som har indendørsarbejde og arbejder under lave dagslysniveauer, og kan fx få indflydelse på fremtidig design af indendørs arbejdspladser. Samlet set giver resultaterne ikke anledning til at ændre på de nuværende anbefalinger om at minimere mængden af natarbejde og antallet af nattevagter i træk.

Abstract

The overreaching aim was to examine possible health effects related to the light environment of indoor work, night work and outdoor work. Specifically we aimed at analyzing if: 1) exposure to low levels of daylight during indoor work increases the risk of depression, sleep disturbances, and general symptoms; 2) exposure to high levels of light during night work increases the risk of breast cancer; 3) low levels of light during indoor work and high levels of light during night work disturbs the circadian rhythm.

We observed no increased risk of breast cancer following recent night shift work among 155,569 workers employed in hospitals and other public institutions within the Danish Regions between 2007 and 2012. The news value of this finding as well as the methodology used was considerable. In 2007, the International Agency of Cancer (IARC) classified night shift work as probably carcinogenic to humans based partly on epidemiological studies. However, these studies suffered from methodological limitations, mainly recall bias related to night shift work information. We accounted for this by using detailed day-by-day work hour information from pay roll registers that we linked with cancer registers and several other national registers. Yet, further research into long-term consequences of night work, which was not studied here, is needed.

We examined if night work suppresses melatonin (circadian hormone) concentration in saliva during days with night work and days off work among 341 night workers, outdoor day workers and indoor day workers. All participants were followed for seven days with continuous light level measurements, repeated saliva sampling (> 2000 saliva samples in all), and diary recordings of working hours. We analyzed if light exposure mediates the association between night work and salivary melatonin concentration. This has not previously been done among night workers during usual working conditions. Our analyses showed lower melatonin concentration during days with night work compared with days with day work. This difference was partly mediated by light exposure during night. However, only few night workers were exposed to high levels of light on the night shift. We observed no difference in melatonin levels between night and day workers on days off work. We thus could conclude that night work has a transient and partly light mediated effect on melatonin production, but most night workers of this study were exposed to low levels of light when working the night shift.

Within the same group of night workers, outdoor day workers and indoor day workers we examined if depressive symptoms and sleep are associated with daylight exposure level. These analyses were the bases of a master thesis in health science and a bachelor thesis in public health sciences at the Faculty of Health, Aarhus University. At present, the results have not been peer reviewed in a scientific journal.

We have assessed 24 hour light exposure levels during work days and days off in 535 night workers, outdoor day workers and indoor day workers. Findings have been presented at scientific conferences and will be used for exposure assessment in future studies of depression and other health effects that may be related to light exposure in the whole Danish working population.

Our findings concerning recent night work are reassuring and will be included in future reviews and classifications of night work as a human carcinogen. Results of the melatonin analyses do not point towards a persistent but a transient effect of night work and support the conclusion concerning breast cancer. Analyses of melatonin during night work and days off will have impact on recommendations for optimal work hour arrangements with relevance for the many working during night. Findings for daylight exposure levels in different occupations will e.g. be relevant for the many who are exposed to low levels of light during indoor work and may affect future design of indoor work sites. For now the results do not give reason to change the recommendation on minimizing night work and number of consecutive night shifts.

Formål

En stor del af befolkningen arbejder indendørs (80-90%) eller har skiftende natarbejde (ca. 20%) i et lysmiljø, som afviger radikalt fra det naturlige lysmiljø. Ved indendørsarbejde er lysniveauet om dagen 100-1000 gange lavere og om natten 10-100 gange højere end udendørs. Udsættelse for lave niveauer af lys om vinteren forårsager vinterdepression, søvnforstyrrelser og almensymptomer, og lysterapi er en effektiv behandling. Men der er stort set ingen viden om, hvorvidt udsættelse for lave niveauer af dagslys ved indendørsarbejde har helbredskonsekvenser. Udsættelse for høje niveauer af lys om natten kan forstyrre døgnrytmen og er mistænkt for at kunne forårsage brystkræft. Brystkræft efter mange års natarbejde kan i Danmark anerkendes som arbejdsskade, men internationalt diskuteres det intenst om udsættelse for lys om natten ved natarbejde er kræftfremkaldende.

De overordnede formål med LUX@R projektet var at undersøge om lysmiljøet ved indendørsarbejde og natarbejde har helbredsmæssige konsekvenser: 1) Om udsættelse for lave niveauer af lys om dagen ved indendørsarbejde giver forøget risiko for depression, søvnforstyrrelser og almensymptomer. 2) Om udsættelse for høje niveauer af lys om natten ved natarbejde giver forøget risiko for brystkræft. 3) Om udsættelse for lave niveauer af lys ved indendørsarbejde og høje niveauer af lys ved natarbejde ændrer den biologiske døgnrytme.

For at besvare disse forskningsspørgsmål udførte vi to separate studier, et registerstudie af natarbejde og brystkræft og et feltstudie af lyseksponering, melatoninproduktion, søvn og depression blandt natarbejdere, udendørs dagarbejdere og indendørs dagarbejdere.

I registerstudiet ville vi besvare følgende specifikke forskningsspørgsmål: 1) Om natarbejde det seneste år til de seneste fem år er forbundet med en forøget risiko for brystkræft, 2) Om effekten af natarbejde inden for de seneste seks år har forskellige effekter på brystkræft-undertyper defineret ud fra østrogen (ER) og human epidermal growth factor 2 (HER2) receptor status og 3) Om antallet af konsekutive nattevagter er forbundet med en forøget risiko for HER2+ brystkræft og for brystkræft generelt.

I feltstudiet ville vi besvare om 1) Natarbejde nedsætter melatonin produktionen under og efter natarbejde, og 2) En eventuel effekt af natarbejde blev medieret af udsættelse for lys, 3) Lysniveauet på arbejdet er associeret med depressive symptomer og 4) Lysniveauet om morgenen hænger sammen med søvnlængden den efterfølgende nat, og 5) Kortlægge lysniveauerne ved natarbejde, udendørs dagarbejde og indendørs dagarbejde.

Metoder og udførelse

Registerstudie af natarbejde og brystkræft

Studiet var baseret på en kohorte af 155.569 offentligt ansatte kvinder i regionerne mellem 2007 og 2012, som indgik i Dansk Arbejdstids Database (DAD). For hver kvinde var der objektive, detaljerede og daglige oplysninger om natarbejde fra regionernes lønregistre. Oplysninger om brystkræftdiagnoser hentede vi i Danish Breast Cancer Corporative Group (DBCG) kliniske database, som også indhold HER2 og ER receptor status. CPR registeret oplyste køn, vital status, fødselsdato, børn og deres fødselsdato, samt førstegradsslægtninge siden 1968. Cancerregisteret leverede oplysninger om kræfttilfælde opstået inden DBCG blev oprettet. Lægemiddelregisteret oplyste recepter udløst på hormonbehandling og midler mod alkoholisme (konkurrerende risikofaktorer for brystkræft). Fra Danmarks Statistik fik vi oplyst uddannelsesniveau. Registeret over mammografiscreening, fik vi oplyst kvinder, som var indkaldt eller havde deltaget i mammografiscreening siden 2007. Vi analyserede data med multivariate Poisson regressionsmodeller, hvor vi qua de omfattende registerdata kunne kontrollere for en række potentielle confoundere.

Feltstudie af lyseksponering, melatoninproduktion, søvn og depression blandt natarbejdere, udendørs-arbejdere og indendørs dagarbejdere

Vi rekrutterede 535 natarbejdere, udendørs dagarbejdere og indendørs dagarbejdere, som vi fulgte i 7 fortløbende dage på arbejde og i fritiden. De bar en lysmåler (Philips Respironics Actiwatch Spectrum) på den ene overarm, når de var vågne, og lagde lysmålere ved siden af sengen, når de sov. 341 af deltagerne opsamlede i alt 2842 spytprøver (i gennemsnit 8.3 per deltager) spredt over to dage, som blev analyseret for melatonin koncentration og indgik i de statistiske analyser. Deltagerne udfyldte et spørgeskema om bl.a. personlige karakteristika og depressive symptomer og en dagbog over arbejdstider og hvornår de faldt i søvn og vågnede.

Vi analyserede sammenhængen mellem natarbejde og melatonin i multilevel lineære regressionsmodeller og vurderede i hvilket omfang lyseksponeringen den sidste ½ time (det relevante tidsvindue) medierede sammenhængen mellem natarbejde og melatonin koncentrationen. Vi sammenlignede lysniveauer for natarbejdere, udendørs dagarbejdere og indendørs dagarbejdere på arbejde og i fritiden. Vi tog højde for tid på døgnet og årstid samt andre potentielle confoundere ligeledes vha. multilevel lineære regressionsanalyser. Risiko for depressive symptomer analyserede vi med standard logistisk regression.

Resultater: Om projektets formål og hensigt er blevet opnået

Registerstudie af natarbejde og brystkræft

Vi fandt ingen forøget risiko for brystkræft, hverken som funktion af natarbejde det seneste år, de seneste fem år eller for konsekutive nattevagter indenfor de seneste seks år. Vi fandt en 35 % forøget risiko for HER2+ brystkræft blandt kvinder, som havde natarbejde indenfor de seneste seks år. Denne risiko var yderligere forøget blandt kvinder, som havde arbejdet flere nattevagter i træk indenfor de seneste seks år. Risikoen så ud til at stige med stigende antal konsekutive nattevagter, men ingen af disse fund var statistisk signifikante. Der var ingen forøget risiko for ER+/HER2- eller ER-/HER2- brystkræft blandt kvinder, som havde natarbejde indenfor de seneste seks år.

Feltstudie af lyseksponering, melatoninproduktion, søvn og depression blandt natarbejdere, udendørs dag-arbejdere og indendørs dagarbejdere

Vores omfattende og tidsspecifikke målinger af melatonin hen over døgnet samtidig med kontinuerlig måling af lysintensitet gjorde os i stand til at vurdere den medierende effekt af lys på dage med natarbejde.

Vi fandt at natarbejdere havde 15 % lavere melatonin koncentrationen på arbejdsdage end dagarbejdere og 15% lavere mealtonin koncentration på dage med natarbejde end på dage med dagarbejde. Lyseksponering om natten medierede en 6% forskel i melatonin koncentrationen. Vi fandt ingen forskel i melatonin niveauer mellem dag- og natarbejdere på fridage.

Vi fandt, som forventet, at alle tre erhvervsgrupper var udsat for højere lysniveauer om sommeren end om vinteren. Om natten var natarbejdere i gennemsnit udsat for væsentligt højere niveauer af lys end indendørs og udendørs dagarbejdere, men mindre end tærskelværdien for suppression af melatonin. Om dagen var indendørs dagarbejdere på arbejdsdage i gennemsnit eksponeret for 1000 lux i arbejdstiden om sommeren og 300-400 lux om vinteren. I samme tidsinterval var udendørsarbejdere udsat for 4000-5000 lux om sommeren og 1000-2000 lux om vinteren.

Vi fandt visse holdepunkter for en sammenhæng mellem forekomsten af depressive symptomer og lysniveauerne på arbejdsdage, men disse data er ikke færdiganalyseret og har ikke været fagfælle bedømt i et videnskabeligt tidsskrift.

Erfaringer og konklusioner

Vi fandt ingen forøget risiko for brystkræft ved nyligt natarbejde. Dette fund og den metodemæssige tilgang har videnskabelig nyhedsværdi. I 2007 klassificerede the International Agency of Cancer (IARC) natarbejde som sandsynligt kræftfremkaldende for mennesker baseret bl.a. på epidemiologiske studier. Disse undersøgelser var dog behæftet med større metodemæssige svagheder, primært informationsbias relateret til

selvrapporterede eksponeringsoplysninger. Det tog vi højde for ved at anvende præcise dag-til-dag arbejdstidsoplysninger fra lønregistre, som vi koblede bl.a. med cancerregistre og en række andre offentlige registre. Fundet af forøget forekomst af HER2+ brystkræft var ikke statistisk signifikant og ikke en a priori hypotese og yderligere studier må af- eller bekræfte dette fund.

Vi fandt, at natarbejde har en forbigående supprimerende effekt på melatonin, som delvist medieres af udsættelse for lys om natten. Men de fleste natarbejdere i dette studie var udsat for lysniveauer, når de var på vagt, som lå under tærskelværdien for suppression af melatonin.

Perspektiver: Hvordan projektets resultater på kort og langt sigt kan bidrage til at forbedre arbejdsmiljøet

Vores resultater vedrørende nyligt natarbejde og brystkræft er beroligende og vil indgå i den samlede vurdering af om natarbejde skal klassificeres og reguleres som kræftfremkaldende. Analyserne af melatonin er også beroligende og vil få betydning for fremtidige anbefalinger om tilrettelæggelse af natarbejde, som vil være relevant for de mange som ikke kan undgå at arbejde om natten. Fundene vedrørende lyseksponeringsniveauer er bl.a. relevant for de mange, som har indendørsarbejde og arbejder under lave dagslysniveauer, og kan fx få indflydelse på fremtidig design af indendørs arbejdspladser. Samlet set mener vi ikke at der er basis for at ændre de nuværende anbefalinger om at minimere natarbejde og antallet af nattevagter i træk.

Publikationer og produkter fra projektet

Skriftlig videnskabelig formidling med fagfælle bedømmelse

Bonde JP1, Hansen J, Kolstad HA, Mikkelsen S, Olsen JH, Blask DE, Härmä M, Kjuus H, de Koning HJ, Olsen J, Møller M, Schernhammer ES, Stevens RG, Åkerstedt T. Work at night and breast cancer--report on evidence-based options for preventive actions. Scand J Work Environ Health. 2012 Jul;38(4):380-90.

Markvart J, Hansen ÅM, Christoffersen J. Comparison and Correction of the Light Sensor Output from 48 Wearable Light Exposure Devices by Using a Side-by-Side Field Calibration Method. LEUKOS: The journal of the Illuminating Engineering Society of North America. 2015: 155-171.

Garde AH, Hansen J, Kolstad HA, Larsen AD, Hansen AM. How do different definitions of night shift affect the exposure assessment of night work? Chronobiol Int. 2016;33(6):595-8.

Vistisen HT, Garde AH, Frydenberg M, Christiansen P, Hansen AM, Hansen J, Bonde JP, Kolstad HA. Short-term effects of night shift work on breast cancer risk: A cohort study of payroll data. Scand J Work Environ Health. 2017 Jan 1;43(1):59-67.

Daugaard S, Garde AH, Bonde JPE, Christoffersen J, Hansen AM, Markvart J, Schlunssen V, Skene DJ, Vistisen HT, Kolstad HA. Night work, light exposure and melatonin on work days and days off. Chronobiol Int. 2017;34(7):942-55.

Øvrig skriftlig videnskabelig formidling

Vistisen HT. Short term effects of night shift work on risk of overall breast cancer and breast cancer classified by oestrogen and HER2 receptor status PhD dissertation, Health, Aarhus University, 2015.

Ida Katrine Thomsen. Low Levels of Light Exposure at Work and Risk of Depression. Master Thesis. Den Sundhedsfaglige Kandidatuddannelse, Health, Aarhus University: 2015.

Anna Huus Eriksson. Morning Light Exposure on Workdays and Self-Reported Sleep Duration: A Cross-Sectional Study on Danish Day workers. Bachelor Thesis Bsc programme in Public Health Sciences, Aarhus University: 2016

Kolstad HA, Garde AH, Hansen AM, Frydenberg M, Christiansen P, Vistisen HT, Bonde JP. Response to Dr. Stevens' letter ref. Visitisen et al: "short-term effects of night shift work on breast cancer risk: A cohort study of payroll data". Scand J Work Environ Health. 2017 Jan 1;43(1):96.

Stine Daugaard Pedersen. Occupational light exposure, melatonin, and vitamin-D. PhD dissertation, Health Aarhus University, 2017

Manuskripter indsendt til videnskabeligt tidsskrift eller under udarbejdelse

S. Daugaard, AH. Garde, JP. Bonde, J. Christoffersen, AM. Hansen, J. Markvart, V. Schlünssen, HT. Vistisen, HA. Kolstad. Light exposure levels during days with night, outdoor, and indoor work and days off.

Mundtlig videnskabelig formidling

Vistisen HT. Night work and breast cancer risk among women in the public Danish Health care sector – a short-term follow up of a large scale population. The 24th International Epidemiology in Occupational Health (EPICOH) Conference, June 24-27, 2014, Chicago, IL.

S. Daugaard, Poster: ISEE Indoor work, ultraviolet radiation, light exposure, and the risk of depression and multiple sclerosis. Young Researchers Conference on Environmental Epidemiology, Barcelona Oct 2014

Henrik Kolstad, Pascal Guenel, Mikko Härma, Jørn Olsen. Symposium: Epidemiology of shift work, breast cancer, and other health effects. Aarhus University, Aarhus: December 18; 2015

Kolstad HA. Short term risk of breast cancer following night shift work in the public healthcare sector: a register linkage study of pay roll data. The 22nd International Symposium on Shiftwork and Working Time. Helsingør: 08/06/2015

Stine Daugaard. Night work, light exposure, and melatonin on work days and days off, PH.D day Aarhus University: January 2016

Stine Daugaard. Occupational Light Levels in Night Shift, Outdoor, and Indoor Daytime Workers, The 25th International Epidemiology in Occupational Health (EPICOH) Conference, September 2016, Barcelona

Henrik Kolstad. Strategies for the prevention of the health effects of night shift work. Panel discussion, The 25th International Epidemiology in Occupational Health (EPICOH) Conference, 2016, Barcelona

Stine Daugaard. Night work, light exposure, and melatonin on work days and days off, Ramazzini Seminar, Sandbjerg: October 2016

Stine Daugaard. Night work, light exposure, and melatonin on work days and days off. WINC-WOW symposium. Stress Research Institute, Stockholm University, 17.11.2016

Henrik Kolstad. Short term effects of night shift work on breast cancer risk: a cohort study of payroll data. WINC-WOW symposium. Stress Research Institute, Stockholm University: 17.11.2016

Jakob Markvart. Light exposure assessment of Danish indoor, outdoor and night-shift workers - Experiences from a field study Workshop Light, health and shift work. Dortmund: October 13, 2016

Stine Daugaard Pedersen. Occupational light exposure, melatonin and vitamin D. EPICOH 2017: 26th International Epidemiology in Occupational Health. Edinburgh, Storbritannien. 28-31 aug. 2017

Mundtlig populær formidling
Henrik Kolstad. Skal vi undgå natarbejde for at forebygge brystkræft? Temadag om helbred og natarbejde, Region Midtjylland. 15. marts 2011 kl. 12.30-16. på Scandic Hotel Silkeborg

Henrik Kolstad. For meget og for lidt lys ved natarbejde og indendørsarbejde, betyder det noget for helbredet? Lys som forbedrer sundhed & trivsel i hospitalssektoren. SBI konference. København: 22. november, 2011

Henrik Kolstad. Night shift work and risk of breast cancer – review of the epidemiological evidence up to 2007 requested by the Danish National Occupational Injury Board. Work at night and breast cancer: Evidence-based options for preventive actions, Copenhagen, October 26-27, 2011.

Henrik Kolstad. Natarbejde og brystkræft: Evidensbaserede forebyggelsesmuligheder. Regionshospitalet Viborg 13. august 2012, Hovedmed udvalget (HMU) ved Aarhus Universitetshospital, 24. september 2012 og Regionshospitalet Randers 3. oktober 2012

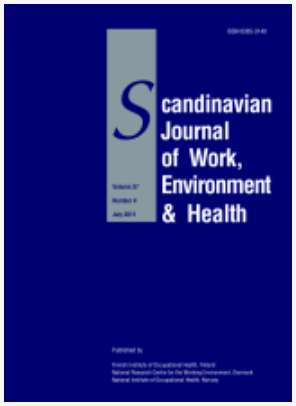
Henrik Kolstad. Årlige informationsmøder om natarbejde og helbred for ansatte i Region Midtjylland

Øvrige artikler, nyheder og hjemmesider
Kom i godt humør med udendørs arbejde . Videnskab.dk., 13. april 2011.
(www.videnskab.dk/krop-sundhed/kom-i-godt-humor-med-udendorsarbejde)
Lys som den store humørspreder, Arbejdsmiljøviden, 23. august 2011
(www.arbejdsmiljoviden.dk/Aktuelt/Nyheder/2011/08/23-lys-projekt)

Gør lys os virkelig i godt humør? Videnskab.dk, 11 august 2011 (www.videnskab.dk/krop-sundhed/gor-lys-os-virkelig-i-godt-humor)
Det måske farlige natlys. Midtnyt, november 2012.
Lys spreder humør på jobbet. BAR transport og engros: dato?
(www.bartransportogengros.dk/Default.aspx?ID=3669&M=News&PID=7157&NewsID=3463)
Kortvarigt natarbejde øger formentlig ikke risiko for brystkræft. Videnskab.dk, 2.12.2016.
(http://videnskab.dk/krop-sundhed/kortvarigt-natarbejde-oeger-formentlig-ikke-risiko-for-brystkraeft)

Ny AUH-forskning viser, at natarbejde i en kort årrække ikke øger risiko for brystkræft. Kræftens Bekæmpelse 6.12.2016. (https://www.cancer.dk/Nyheder/Presseklip/?resultsPerPage=100).
Få års natarbejde giver ikke øget risiko for brystkræft. Mit arbejdsmiljø februar 2017.
(https://mitarbejdsmiljo.dk/artikler/faa-aars-natarbejde-giver-ikke-oeget-risiko-brystkraeft)
Resultaterne om brystkræft har været præsenteret på møder for Arbejdstidsfølgegruppe (januar 2017) og DAD følgegruppe (marts 2017).

Bilag 1. Skriftlig videnskabelig formidling med peer review



Consensus report

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Work at night and breast cancer – report on evidence-based options for preventive actions

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Affiliation: Department of Occupational and Environmental Medicine, Bispebjerg University Hospital, Bispebjerg Bakke 23, DK-2400 Copenhagen NV, Denmark. jbon0004@bbh.regionh.dk

Key terms: breast cancer; cancer; circadian rhythm; evidence-based option; melatonin; night work; occupational disease; prevention; shift work

Consensus report

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Work at night and breast cancer – report on evidence-based options for preventive actions

by Jens Peter Bonde, MD, DMSc,[1] Johnni Hansen, MSc, PhD,[2] Henrik A Kolstad, MD, PhD,[3] Sigurd Mikkelsen, MD, DMSc,[1] Jørgen H Olsen, MD, DMSc,[2] David E Blask, MD, PhD,[4] Mikko Härmä, MD, PhD,[5] Helge Kjuus, MD, PhD,[6] Harry J de Koning, MD, PhD,[7] Jørn Olsen, MD, PhD,[8, 9] Morten Møller, MD, DMSc,[10] Eva S Schernhammer, MD, DrPH,[11] Richard G Stevens, MD, PhD,[12, 13] Thorbjörn Åkerstedt, PhD [14]

Bonde JP, Hansen J, Kolstad HA, Mikkelsen S, Olsen JH, Blask DE, Härmä M, Kjuus H, de Koning HJ, Olsen J, Møller M, Schernhammer ES, Stevens RG, Åkerstedt T. Work at night and breast cancer: Report on evidence-based options for preventive actions. *Scand J Work Environ Health* – online first. doi:10.5271/sjweh.3282

In 2007, the International Agency for Research on Cancer classified shift work involving circadian disruption as probably carcinogenic to humans (group 2A), primarily based on experimental and epidemiologic evidence for breast cancer. In order to examine options for evidence-based preventive actions, 16 researchers in basic, epidemiological and applied sciences convened at a workshop in Copenhagen 26–27 October 2011. This paper summarizes the evidence from epidemiological and experimental studies and presents possible recommendations for prevention of the effects of night work on breast cancer.

Among those studies that quantified duration of shift work, there were statistically significant elevations in risk only after about 20 years working night shift. It is unclear from these studies whether or not there is a modest but real elevated risk for shorter durations. Hence, restriction of the total number of years working night shift could be one future preventive recommendation for shift workers. The diurnal secretion of melatonin by the pineal gland with peak in secretory activity during the night is a good biochemical marker of the circadian rhythm. Disruption of the diurnal melatonin secretion pattern can be diminished by restricting the number of consecutive night shifts. Reddish light and reduced light intensity during work at night could potentially help diminish the inhibitory activity of light with strong intensity on the melatonin secretion, but further mechanistic insight is needed before definite recommendations can be made. Earlier or more intensive mammography screening among female night shift worker is not recommended because the harm–benefit ratio in this age group may not be beneficial. Preventive effects of melatonin supplementation on breast cancer risk have not been clearly documented, but may be a promising avenue if a lack of side effects can be shown even after long-term ingestion. Women with previous or current breast cancer should be advised not to work night shifts because of strong experimental evidence demonstrating accelerated tumor growth by suppression of melatonin secretion.

Work during the night is widespread worldwide. To provide additional evidence-based recommendations on prevention of diseases related to night shift work, large studies on the impact of various shift schedules and type of light on circadian rhythms need to be conducted in real work environments.

Key terms circadian rhythm; melatonin; occupational disease; night work; prevention; shift work.

1 Department of Occupational and Environmental Medicine, Bispebjerg Hospital, University of Copenhagen, Denmark.
2 Institute of Cancer Epidemiology, Danish Cancer Society, Copenhagen, Denmark.
3 Danish Ramazzini Centre, Department of Occupational Medicine, Aarhus University Hospital, Aarhus, Denmark.
4 Department of Structural & Cellular Biology, School of Medicine, Tulane University, New Orleans, Louisiana, USA.
5 Centre of Expertise on Human Factors at Work, Finnish Institute of Occupational Health, Helsinki, Finland.
6 Department of Occupational Medicine and Epidemiology, National Institute of Occupational Health, Oslo, Norway.
7 Department of Public Health, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands.
8 Department of Epidemiology, University of California, Los Angeles, USA
9 Aarhus Universitet, Institut for Epidemiologi og Socialmedicin, University of Aarhus, Aarhus, Denmark.
10 Department of Neuroscience and Pharmacology, University of Copenhagen, Copenhagen, Denmark.
11 Channing Laboratory, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA.
12 Department of Epidemiology, Harvard School of Public Health, Boston, MA, USA.
13 Division of Epidemiology & Biostatistics, Department of Community and Health Care, University of Connecticut Health Center, Farmington, USA.
14 Institute for Stress Research, Stockholm University and Karolinska Institutet, Stockholm, Sweden.

Correspondence to: Jens Peter Bonde, Department of Occupational and Environmental Medicine, Bispebjerg University Hospital, Bispebjerg Bakke 23, DK-2400 Copenhagen NV, Denmark. [E-mail: jbon0004@bbh.regionh.dk]

About 15–20% of employees in Europe and USA work night shifts and an increasing segment of the working population in industrialized countries worldwide work non-day shifts (1). In 2007, the International Agency for Research on Cancer (IARC) classified shift work that involves circadian disruption as "probably carcinogenic to humans" (group 2A) (2, 3). This conclusion was based on (i) sufficient evidence in animal studies for carcinogenicity of light during the daily dark period, (ii) strong experimental data suggestive of a causal link between circadian disruption and development of malignant tumors and (iii) limited epidemiological evidence of increased risk of breast cancer among women working night shifts.

In Denmark, exposures classified by the IARC as carcinogenic to humans (group 1) or probably carcinogenic to humans (group 2A) are considered for inclusion in the list of occupational diseases. Between 2007 and 2011, the Danish National Board of Occupational Injuries recognized some 110 cases of breast cancer as diseases caused by work at night and therefore eligible for compensation. Assuming that work at night indeed contributes to the occurrence of human breast cancer and considering the high prevalence of night work, it has become an important priority to examine if current knowledge allows for evidence-based recommendations of preventive actions. For this purpose, 16 researchers in biological, epidemiological and applied sciences convened at a workshop in Copenhagen, 26–27 October 2011. This report provides a brief account of background information, conclusions and recommendations that emerged from the workshop. While increasing evidence on shift work and cancer risk prompted the workshop, it is acknowledged that preventive measures should also accommodate other known and suspected health risks related to shift work such as sleep disorders, accidents, cardiovascular disease, and metabolic disorders (4). This paper, however, deals with breast cancer only.

Light, circadian rhythms, and melatonin

Circadian rhythms are evident in virtually all living animals and plants. They are genetically encoded and adjusted to local time primarily by an entrainment to the daily photoperiod via light reaching the eye. Circadian rhythms (including, for example, sleep/wake cycles, body temperature, blood pressure, hormone secretion, digestion, metabolism, and cell turnover) are pivotal for survival and driven and maintained in a hierarchical manner by a central pacemaker (the biologic master clock) located in the suprachiasmatic nucleus (SCN) of the hypothalamus. The SCN also orchestrates the independent peripheral clocks in the rest of the organism into a coherent time organization with optimal time structure and biological function for the entire body (5). The endogenous clockwork is entrained to the ambient diurnal light/dark cycle given by the rotation of the earth in relation to the sun, primarily through photosensitive retinal ganglion cells containing the newly detected photopigment melanopsin (peak sensitive to blue light of 460–484 nm). It transmits time of day, duration of the day, and day of year information to the pineal gland by the SCN and the sympathetic nerve system (6). From the pineal gland, the time information is signaled to organs and tissues by secretion of the neurohormone melatonin – a lipophilic indole – and binding to cell membrane-bound melatonin receptors. Melatonin is produced during the biological night (from dusk to dawn), whereas the daytime production is virtually zero. While the peak of the melatonin secretion signals time relative to the astronomical 24-hour light/dark cycle, the duration of the melatonin surge indicates the length of the day, and indirectly the time of the year (season). Exposure to light during night immediately reduces melatonin production dependent of light intensity, wavelength and duration of exposure, and may in addition cause desynchronization of the master clock from the peripheral clocks, including the fine-tuned circadian gene expression in local tissues and cells (7–9). During the last decades, melatonin receptors have been shown to be present in several peripheral tissues outside the brain and also in neoplasms of the mammary gland.

In the scientific literature, the term "circadian disruption" is defined as desynchronization of internal circadian rhythms relative to ambient dark/light cycle, including desynchronization of the SCN with peripheral clocks. Circadian disruption is partly but not fully characterized by change in physiological markers of the circadian rhythm such as amplitude, duration, and timing of melatonin secretion. In a broader sense, circadian disruption describes objective or subjective proxies of changed circadian rhythm (such as sleep disturbance and tiredness). In this paper, the term is used in the broader meaning, unless otherwise specified, recognizing that little is known about the relation between real life shift work and physiological markers of circadian rhythm.

The vast majority of experimental evidence supports the hypothesis that under the conditions of complete darkness, high circulating levels of melatonin during the night not only provide a potent circadian anti-cancer signal to established cancer cells but also help to protect normal cells from the initiation of the carcinogenic process in the first place (7, 8). Most of the earlier studies using experimental models of either spontaneous or chemically induced rodent models of mammary carcinogenesis demonstrate an accelerated development of mammary tumors in response to exposure to constant bright fluorescent light at night. More recent experimental work demonstrates that chronically advancing the phasing of light exposure (chronic jet

lag) plays a significant role in malignant progression in tumor-bearing mice (10). Thus a change of the timing of the light/dark cycle by steady phase advances in light exposure may represent a potentially important biological mechanism for increased cancer growth.

Studies of female rats bearing human breast cancer xenografts show that growth and metabolic activity of tumors increase significantly as the intensity of light exposure increases, and that these effects are caused by a corresponding suppression of nocturnal melatonin secretion. Moreover, mechanistic evidence indicates that the ability of the nocturnal melatonin to suppress tumor fatty acid uptake and metabolism, particularly linoleic acid, is compromised by circadian disruption (8). This experimental evidence provides a link between exposure of healthy human female subjects to light at night and enhancement of human breast oncogenesis via suppression of the nocturnal melatonin anti-cancer signal. The suppression of melatonin production by exposure to light at night, leading to augmented tumor growth and linoleic uptake/metabolism deserves serious consideration as a potential biological mechanism to explain the association between breast cancer and night shift work.

Melatonin is the most stable and reliable biological marker of circadian rhythm in humans and therefore information on how shift systems and light exposure affects melatonin homeostasis is important when considering options for preventive actions (11). Four out of five prospective cohort studies among women without night work have shown increased risk of breast cancer related to low urine levels of the melatonin metabolite, 6-sulfatoxymelatonin in morning spot samples or 24 hour samples (12–16). Unfortunately there are only few studies that in some detail outline the melatonin exposure profile (peak, amplitude, duration, timing) among people working night shifts (17–20) except among nurses working in fast-forward-rotating shifts (21). These studies report a small reduction (typically less than 20%) in melatonin secretion and a flattened secretion profile among night compared to day workers. Changes seemed more pronounced among permanent night workers but were also found for other shift workers after the night shift (18). Although light with wavelength 460–480 nm creates the strongest suppression of melatonin (22), even dim red light causes suppression; work in constant dim red light is hardly a realistic option since most work tasks require better lighting conditions for safety and productivity reasons.

The IARC evaluation in 2007

The IARC evaluation included three cohort studies (two of them prospective) and five case–control studies addressing the risk of breast cancer in relation to various definitions of non-day work, including evening, night, and early morning shifts as defined by self-reports or estimated from job exposure matrices (23–30). Six of the eight studies showed increased relative risk in the range of 1.4–2.2 when extreme categories of non-day work were compared (23–28). Data on the overall relative risk for breast cancer according to uniform definitions of night shift work cannot be directly obtained from the studies. Moreover, eight of nine cohort studies of flight attendants – who may be exposed to both jetlag, cosmic radiation, and shift work – reported increased risk of breast cancer (3). Other studies addressing risk of breast cancer in occupations with a high prevalence of night work were not included in the IARC evaluation. All three studies of nurses reported significantly increased risk for breast cancer for night shift work beyond 20–30 years in the range of 1.4–2.2 (24–26).

Update of the epidemiologic evidence

Since the IARC evaluation, four additional observational studies have been published, three of which were case–control studies (31–33) and one cohort study (34). In general these studies tended to cover more details concerning shift systems (eg, rotating versus permanent shift and number of consecutive shifts) compared to the older studies, which in particular focused on duration. Two case–control studies nested within cohorts of nurses indicate an association between night shift work and breast cancer after adjustment for most known potential confounders (32, 33). In the Lie et al study (32), an increased risk is observed among nurses with ≥5 consecutive night shifts during ≥5 years, while in the Hansen & Stevens study (33) an increased risk is observed even after a short duration of night shift work. The two other studies indicated no overall effect of night shift work (31, 34), but the Pesch et al study (31) reported a non-significantly increased risk with cumulative number of night shifts. None of the studies had sufficient power to stratify on different histologic subtypes of breast cancer or age of onset for breast cancer (eg, pre-, postmenopausal cancer). Only one of the four studies adjusted for participation in breast cancer screening activities. Uncontrolled confounding by screening could potentially contribute to underestimation of risk of breast cancer if screening is less frequent among night workers, which is indicated by some data (31). This is because screening not only detects cancer at an earlier stage but also breast cancers that would not progress to clinical detection. An overview of breast cancer risk according to non-day shift work is provided in table 1 based upon the 12 epidemiological studies included in this report.

A main limitation of epidemiological studies so far is uncertainty in how best to define work schedules and crude quantification of work at night across studies. Thus, exposure misclassification in studies using exposure matrices may diminish exposure contrasts, thereby reducing the ability to identify effects whereas recall bias in the case–control studies may generate a spurious association or overestimate a true risk. Further limitations are uncertain exposure–response relationships and findings restricted to few specific occupations (ie, nursing) in 5 out of 12 studies.

How to prevent circadian disruption?

Disruption of the circadian rhythm is assumed to be a main pathway from shift work to disease, although other mechanisms may also be involved (35). This applies not only to risk of cancer but also to other known and suspected shift-work-related disorders (1). Complete elimination of work at night is not foreseeable in either low- or high-income countries. Therefore it is important to identify and implement shift systems that minimize circadian disruption and other factors that might be involved in carcinogenicity such as behavioral and lifestyle factors.

The degree of circadian adjustment varies significantly in relation to shift schedules, although the evidence is still limited (36–39). Factors influencing the degree of circadian disruption are mostly related to specific shift characteristics like timing, speed (ie, number of consecutive night shifts), duration and direction of shift rotation as well as factors related to the actual light exposure (intensity, wavelength and timing). On the other hand, also individual factors (eg, diurnal preference and sleep pattern) and other environmental factors (eg, eating and lighting when not at work) influence the circadian adjustment.

Cumulative number of years working nightshifts

Setting limits to the total lifelong "work at night" dose in analogy with guidelines on cumulative radiation dose would be justified if reliable knowledge on cancer risk in relation to cumulative night work exposure were available. For those studies that quantified duration, statistically significant increases in risk were only seen for ≥20 years; but it is unclear from the existing studies whether or not there is risk for shorter durations (table 1). Overall there is no clear pattern of increased risk with increasing number of years working at night. Moreover, a threshold value separating risk and no-risk cannot currently be identified.

Cumulative number of night shifts

Night shift work per se is not expected to be a risk factor of breast cancer but is an upstream cause for light-at-night exposure, melatonin suppression, circadian phase shift, and sleep deprivation, which may be more proximal determinants of breast cancer. In any case, one would expect that breast cancer risk increases as the cumulative number of nightshifts increase (40, 41). Since the cumulative number of night shifts was analyzed using different metrics in the six epidemiological studies addressing this issue (27, 28, 31–34), the consistency of results cannot be evaluated without access to raw data.

Number of consecutive night shifts

An alternative strategy to diminish circadian disruption is to minimize the number of consecutive nightshifts in order to prevent circadian adjustment and maximize recovery to the normal day-oriented sleep/wake rhythm. Even rapidly rotating shifts may cause sleep deprivation and should therefore be organized with between-shift periods of sufficient duration to allow for full recovery in terms of rest and sleep (42). Based on most studies and recommendations, the use of forward-rotating shift systems (1–2 consecutive night shifts) seems to be more favorable for sleep, performance, and the social life of the workers than the use of more slowly rotating shift rotations (3–5 consecutive nightshifts) (4, 36, 37, 42). Rapidly forward-rotating shift systems also suit older workers better because of their shortened day sleep after a night shift and hence decreased adjustment to consecutive night shifts (42, 43).

Epidemiologic evidence indicating that working slowly rotating shift systems (working consecutively 4–5 or more nights) is related to a higher risk of breast cancer has only been reported in one study (32) and indirectly in another study reporting the highest breast cancer risk among nurses with periods of both permanent night shifts and rotating shifts compared to nurses with rotating shifts only (33).

Number of nightshifts per month

One early study (31) showed an increased risk of breast cancer with increasing average number of night shifts per month but two later studies did not (32, 34).

Working permanent night shifts

Since most permanent night shift workers return to a normal diurnal rhythm during days off, they are not expected to have a risk for breast cancer that differs from workers on rotating night shift work beyond the

potential effect of number of shifts. However, little is known about differences between specific night shift schedules in relation to the cumulated melatonin excretion, eg, if permanent night shift differs from slow- or fast-rotating shifts with respect to cumulated melatonin secretion over a longer time period with the same number of night shifts. So far, only one study has reported risk for breast cancer for permanent and rotating nightshifts separately (33). In remote work sites, it may be feasible to combine permanent nightshifts with a switch of the day/night rhythm during days off work and thus achieve circadian readjustment over extended periods of time. Detailed measures of melatonin across different work shift periods in longitudinal cohorts are warranted.

Intensity of light at night

Experimental studies show that white light provides a strong signal to the brain centre regulating the circadian rhythm and produces the most pronounced suppression of melatonin secretion from the pineal gland (the maximum effect in the blue end of the spectrum, ie, at wave length 460–480 nm) (44, 45). Thus, exposure to bright white light during night shifts may be used to stimulate adaptation to night work, if desirable (46) (eg, for permanent night workers), but bright white light should be avoided if such adaptation is not desirable (eg, in fast-rotation shifts where dim red light is preferable when possible and safe considering the work tasks). Similarly, permanent night shift workers should avoid bright light after work (eg, by using dark sun-glasses) and return home to sleep, while fast-rotating shift workers should be exposed to the morning bright light in order not to change the normal circadian rhythm. Bright light exposure during the first half of the biological night (before the melatonin peak) will delay the circadian rhythm, and bright light exposure during the latter half, after the melatonin peak, will advance the rhythm (47). The effects of implementation of light exposure regimens to delay or advance the circadian rhythm may therefore be unpredictable at the individual level, depending on their circadian phase when they are exposed to light. Large intervention studies are needed before specific light exposure regimens are recommended for night shifts in different types of shifts.

Nutritional issues

Dietary factors may influence cancer growth and metabolism (48). Experimental evidence indicates that melatonin partly exerts its anti-proliferative effects by inhibiting uptake of linoleic acid (an essential omega-6 polyunsatturated acid) into the cells (8). There is, however, no human evidence to indicate ameliorating effects of specific diets during night work relative to cancer or other disease risks. Recommendations for a healthy diet to the general population also apply for night shift workers until good research indicates otherwise.

Rest and short sleep periods during night shifts

It is well established that shift work at night is related to poor sleep quality and shorter sleep duration (49), and the latter has been associated with increased risk for breast cancer (50). Periods of rest and "power naps" during night shifts can increase alertness but there is no evidence that power naps reduce circadian disruption or prevent breast cancer.

Vulnerability in shift work

There is no available data on vulnerability to cancer among shift workers but several studies have examined individual factors related to outcomes such as being able to cope with shift work, fatigue, and sleepiness (51). Factors like aging and being predisposed to an earlier circadian phase ("morningness") decrease the speed of adaptation to consecutive night shifts. Eveningness compared to morningness seems to facilitate permanent night work, but not rotating shift work. Shift workers who are transferred to day work become more morning types. During the last few years, there has been some focus on the shift work disorder: sleep or alertness problems supposedly characterizing individuals working at night but the prevalence of these disorders among day workers is unknown.

Research into clock genes and other genes of importance for circadian rhythm is at an early stage (52) and so far there is no reliable genetic test that can identify persons who are more sensitive to circadian disruption than others. In general, primary or secondary preventive action independent of individual genetic disposition is recommended since the working environment should be organized to suit all workers.

Mammography screening

Breast cancer screening is offered to the female population in the age range 50–74 years in many countries regardless of risk status. Extending breast cancer screening to pre-menopausal women working night shifts has been considered. However, the harm–benefit ratio is higher among women <50 years unless a very strong risk factor (eg, first line family occurrence) is present. Considering the magnitude of risk related to work at night (if any, a relative risk ≤2), it is not justified to recommend

Table 1. Shift–work and breast cancer risk studies in chronology order by duration and cumulative number of nights. [ND=not determined; RR=relative risk; 95% CI=95% confidence interval; P–value=test for trend]

Study (country)	Study design (period)	Non-day time work exposure definition	Duration of non-daytime work					Cumulative night shift				
			Exposure categories	Cases (N)	RR	95% CI	P-value	Exposure categories	Cases (N)	RR	95% CI	P-value
Tynes et al, 1996 (Norway)	Nested case–control study on naval radio telegraph operators (1961–91)	Frequent present in radio room both at night and during the day	All	50	1.5	1.1–2.0						
			<50 years					<50 years				
			None	3	1	reference		None	12	1.0	reference	
			>0–3.2 years	13	0.9	0.2–3.7	0.80	Low	5	0.4	0.1–1.2	0.87
			3.2–14.6 years	13	0.8	0.2–3.6		High	29	0.9	0.3–2.3	
			≥50 year					≥50 years				
			None	1	1.0	–		None	3	1.0	reference	
			>0–3.2 years	5	1.9	0.2–17.9	0.02	Low	6	3.3	0.8–13.7	0.01
			3.2–14.6 years	15	5.9	0.7–47.7		High	12	6.1	1.5–24.2	
Hansen 2001, (Denmark)	Population-based nested case–control based on register data (1964–94)	Working at least half a year at least 5 years prior to reference date in trades where at least 60% of survey responders had non–day time schedules	Day time	5847	1	reference						
			All night work	434	1.5	1.3–1.7	ND					
			>6 years	117	1.7	1.3–1.7						
Davis et al, 2001, (USA)	Case–control (1992–95)	Graveyard shift: beginning work after 19:00 hours and leaving work before 09:00 hours	No graveyard shift	713	1	reference						
			Ever	51	1.6	1.0–2.5						
			Reference	733	1	reference						
			<3	15	1.3	0.6–3.2	0.04					
			≥3 years	19	1.4	0.8–3.2						
			Per year	767	1.13	1.01–1.27						
Schernhammer et al 2001, (USA)	Prospective cohort of nurses (NHS I) (1988–98)	Rotating night shifts: years in total worked at least three nights per month in addition to days or evening in that month	Never	925	1	reference						
			1–14 years	1324	1.1	1.1–1.2						
			15–29 years	134	1.1	0.9–1.3	0.02					
			≥30 years	58	1.4	1.0–1.8						
Schernhammer et al 2006, (USA)	Prospective cohort of nurses (NHS II) (1989–2001)	Rotating night shifts: total months worked for at least three nights per month in addition to days or evening in that month	Never	441	1	–						
			1–9 years	816	1.0	0.9–1.1						
			10–19 years	80	0.9	0.7–1.2	0.65					
			≥20 years	15	1.8	1.1–3.0						
Lie et al, 2006 (Norway)	Register based nested case–control study of nurses (1960–82)	Nurses working at infirmaries (hospitals)	0 years	50	1	reference						
			>0–14 years	362	1.0	0.7–1.3						
			15–29 years	101	1.3	0.8–2.0	0.01					
			≥30 years	24	2.2	1.1–4.5						
O'Leary et al, 2006 (USA)	Case–control study of workers (1996–97)	Evening work: starting afternoon and ending as late as 02:00 hours Overnight work: starting as early as 19:00 hours and continue until the following morning	No evening or overnight shift work	313	1	reference	ND					
			Evening shift only	148	1.2	0.9–1.6						
			Overnight shift only	10	0.6	0.3–1.5						
			<1 evening shift/week	356	1	reference						
			<5 years evening shift	51	0.9	0.6–1.4						
			≥5 years evening shift	79	1.2	0.9–1.8						
			<1 overnight shift/week	469	1	reference						
			<5 years evening shift	11	0.7	0.3–1.7						
			≥5 years evening shift	6	0.3	0.1–0.8						

continued

Table 1. Continued

Study (country)	Study design (period)	Non-day time work exposure definition	Duration of non-daytime work					Cumulative night shift				
			Exposure categories	Cases (N)	RR	95% CI	P-value	Exposure categories	Cases (N)	RR	95% CI	P-value
Schwartzbaum et al, 2007 (Sweden)	Retrospective cohort of female participants from censuses in 1960 and 1970 (1971–89)	Occupation–industry combinations in which ≥40% workers had a rotating schedule with ≥3 possible shifts per day or had work hours during the night (any hour between 01:00–04:00 hours) ≥1 day during the week	Shiftwork, census 1970	70	0.9	0.7–1.2	ND					
			Census 1960 and 1970	28	1.0	0.7–1.4						
Pesch et al, 2008 (Germany)	Population-based case–control (2000–2004)	Working the full–time period between 24.00–05:00 hours for at least 1 year	Employed, never shiftwork	698	1	reference		Employed, never in shiftwork	698	1	reference	
			Ever in night shift	55	0.9	0.6–1.5	ND	<1056 night shifts	25	0.7	0.3–1.3	ND
			>0–4 years	15	0.7	0.3–1.5						
			5–9 years	11	0.9	0.3–2.8		≥056 night shifts	25	1.7	0.7–4.2	
			10–19 years	10	0.8	0.3–2.6						
			≥20 years	12	2.5	0.6–10.0						
Pronk et al, 2010 (China)	Prospective cohort (2000–2007)	Job exposure matrix score (0–3) for likelihood of night shift work	0	423	1	reference		0	423	1	reference	
			>0–≤14 years	108	1.1	0.9–1.3		>0–≤34	102	1.0	0.8–1.3	
			>14–≤25 years	89	0.9	0.7–1.1	0.72	>34–≤66	103	1.0	0.8–1.2	0.84
			>25 years	97	1.0	0.8–1.3		>66	89	1.0	0.8–1.2	
		Self report: starting work after 22:00 hours ≥3 times a month for >1 year	0	276	1	reference		0	276	1	reference	
			>0–≤5 years	25	0.9	0.6–1.3		>0–≤576	27	0.9	0.6–1.3	
			>5–≤17 years	29	0.9	0.6–1.4	0.26	>576–≤1632	28	1.0	0.7–1.5	0.17
			>17 years	19	0.8	0.5–1.2		>1632	18	0.7	0.4–1.1	
Lie et al 2011, (Norway)	Nested case–control study in cohort of nurses (1990–2007)	Permanent and rotating night schedules lasting from ≥24:00–06:00 hours	Never night work		1	reference		Never night work	102	1	reference	
			1–11 years		1.2	0.9–1.5	0.17					
			≥12 years		1.3	0.9–1.8		<1007 night shifts	396	1.2	0.9–1.6	0.24
								≥1007 night shifts	201	1.2	0.9–1.7	
								<5 years night shift				
								≥ 3 consecutive shifts	194	1.1	0.8–1.6	
								≥4 consecutive shifts	160	1.2	0.8–1.6	
								≥5 consecutive shifts	137	1.2	0.8–1.7	
								≥6 consecutive shifts	119	1.2	0.8–1.7	
								≥7 consecutive shifts	109	1.1	0.8–1.6	
								≥5 years night shift				
								≥3 consecutive shifts	278	1.1	0.8–1.5	
								≥4 consecutive shifts	131	1.4	0.9–1.9	
								≥5 consecutive shifts	74	1.6	1.0–2.4	
								≥6 consecutive shifts	64	1.8	1.1–2.8	
								≥7 consecutive shifts	58	1.7	1.1–2.8	
Hansen & Stevens 2011, (Denmark)	Nested case–control study in cohort of nurses (2001–2003)	About 8 hours work per day between 21:00–07:00 hours for ≥1 year	Day and evening	37	1	reference	ND	Day–evening	37	1	reference	ND
			1–5 years	55	1.5	1.0–2.5		<468 night shifts	63	1.6	1.0–2.6	
			5–10 years	70	2.3	1.4–3.5						
			10–20 years	66	1.9	1.1–2.8		468–1095 night shifts	80	2.0	1.3–3.0	
			≥20 years	39	2.1	1.3–2.3		≥1096 night shifts	87	2.2	1.3–3.2	
			Per year	267	1.02	1.01–1.03						

earlier or more intensive mammography screening to female night shift workers by means of present screening technology. The relatively higher harm–benefit ratio in younger women is the result of lower incidence of breast cancer, more false positive tests, and over diagnosing. Any risk due to ionizing radiation conferred by the screening procedure is marginal (53).

Periodic health examinations

Benefits of periodic health examinations of night shift workers are not documented in the scientific literature (54). Periodic health examinations without defined and documented content may cause inappropriate health concern, increased burden on the healthcare system, and inappropriate use of resources (55, 56). The workshop acknowledges that there is a need for counseling of night shift workers regarding more general preventive lifestyle changes, but benefits from general health examinations are disputed.

Treatment with melatonin

From a theoretical point of view, the oncostatic effect of melatonin might be due to different mechanisms: (i) a direct binding of melatonin to the receptors in the tumor tissue, or (ii) an indirect effect via an entrainment of the circadian clock in the SCN or a peripheral clock located in the tumor tissue itself (57). For the direct effect, a constant saturation of the receptor during both day and night would be optimal. Contrarily, to phase-change the central or peripheral clock, a single physiological melatonin dose should be given at a critical certain circadian time point, where the phase response of the circadian clock is maximal. Clinical treatments of cancer, including breast cancer, with large doses of melatonin given at bedtime, have been reported (58), but the value of such a treatment needs empirical support. Melatonin, taken orally, might or might not in the future be useful in the prevention of breast cancer among shift workers, and randomized controlled trials documenting beneficial effects on the circadian rhythm are warranted. Both long-term side effect as well as dose and circadian time point for the medication have to be determined. Investigations of neurotransmitters and receptors in the optic system transmitting light information to pineal gland might result in more effective future drugs than melatonin to restore normal circadian rhythms among shift workers.

Is breast cancer an occupational disease?

The legal definition of an occupational disease and the criteria for recognition and worker compensation varies profoundly between countries. Arguments in favor of recognizing breast cancer as an occupational disease include (i) an increasing number of epidemiologic studies reporting an association between breast cancer and shift work (including nightwork), and (ii) plausible mechanisms linking work at night and breast cancer related to the disruption of circadian rhythms. Arguments against recognition raise the following shortcomings (i) weak associations limited to selected occupational groups, (ii) the poor definition of the nature of shift work, and (ii) unclear exposure–response relationships (59). The current scientific evidence, together with the large differences both in causal requirements and compensation systems between countries, does not allow for a global scientifically based recommendation to include (or not include) breast cancer in national lists of occupational diseases for compensation purposes. However, the scientific evidence of a potentially causal association between night work and breast cancer and the vast documentation of other detrimental health effects from shift work clearly calls for primary prevention, including a limitation of night work.

Concluding remarks and recommendations

Four epidemiologic studies published between 2008 and 2011 provide no reason to revise the IARC's conclusion that shift work involving circadian disruption is probably carcinogenic to humans

In experimental animals, exposure to light during the biological night is strongly linked to an excess risk of tumors. This happens through a biological mechanism that may also operate in humans. In absence of sufficient human data, it is therefore prudent to regard night shift work that includes circadian disruption as carcinogenic.

Epidemiologic studies provide no clear pattern of increased risk with increasing number of years working at night, but studies that quantified the duration of shift work observed elevations in risk only after about 20 years. Restriction of total number of night shifts or number of years working night shift may be considered, although current limited scientific evidence does not allow for more specific recommendations.

Options to limit circadian disruption

- Rapidly rotating shifts (1–2 consecutive nights) cause less disruption of circadian rhythms than slowly rotating shifts (≥3 consecutive shifts);

- Delay of circadian phase causes less circadian disruption than advance of circadian phase and for this reason forward- rather than backward-rotating shifts are recommended;
- Permanent night work is an uncommon solution to avoid circadian disruption and is feasible in remote worksites where a night-oriented rhythm during days off is possible;
- Modified light intensity during work at night such as working in bright white light to increase adoption or in dim red light to prevent adoption may prove feasible methods to minimize circadian disruption, but further research on different light regimens is needed. This also includes studies addressing the optimal trade-off between effects on circadian rhythms and alertness;
- Considering the magnitude of increased risk related to work at night (if any) and because the harm–benefit ratio is unknown, it is at present not justified to offer earlier or more intensive mammography screening to female night shift workers;
- Melatonin supplementation might in the future be useful in the prevention of breast cancer among shift workers, but randomized controlled trials documenting effects on the circadian rhythm and long-term side effects are needed before this is recommended. Both dose and circadian time point for the medication has to be determined;
- Current evidence does not allow a scientifically based recommendation to include (or exclude) breast cancer in national lists of occupational diseases for compensation purposes;
- Women with breast cancer should be advised not to work night shifts because of the strong experimental evidence demonstrating that suppression of melatonin secretion causes augmented tumor growth; and
- The vast documentation of other detrimental health effects from shift work clearly calls for primary prevention including the limitation of night work.

In conclusion, the IARC classification calls for specific preventive actions. Considering the uncertainties in the scientific evidence, specific recommendations to regulate for example the number of years working night shifts, the number of consecutive nightshifts, or the specific spacing and number of night shifts in forward-rotating shift work cannot be scientifically justified from the current knowledge. Decisions on specific preventive measures should be revised as new evidence becomes available.

Research needs

Work during the night is widespread and growing in developing countries. Therefore, understanding the specific risks associated with night work and their biological mechanisms of action are needed in order to minimize such risks on a scientific basis. Recently a working group identified several major domains of non-day shifts and shift schedules that should be captured in future studies (shift system, duration working non-day shifts, and shift intensity) (38). In order to provide more specific and evidence-based recommendations on the prevention of disease related to work at night, more research needs to be conducted on the impact of various shift schedules and the type of light and other exposures on melatonin and the circadian rhythms of workers in real-work environments (38). There is some evidence that long-term shift work leads to promoter methylation changes in specific circadian genes as well as whole genome wide alterations (60), and studies on epigenetic changes induced by shift work along the life course are needed.

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References

1. Rajaratnam SM, Arendt J. Health in a 24-h society. Lancet. 2001;358(9286):999–1005. http://dx.doi.org/10.1016/S0140-6736(01)06108-6.
2. Straif K, Baan R, Grosse Y, Secretan B, El GF, Bouvard V, Altieri A, Benbrahim-Tallaa L, Cogliano V. Carcinogenicity of shift-work, painting, and fire-fighting. Lancet Oncol. 2007;8(12):1065–6. http://dx.doi.org/10.1016/S1470-2045(07)70373-X.
3. International Agency for research on Cancer. Painting, firefighting and shift work. Lyon: IARC; 2010. p. 9–764.
4. Härmä M. Workhours in relation to work stress, recovery and health. Scand.J Work Environ.Health. 2006;32(6):502–14. http://dx.doi.org/10.5271/sjweh.1055.
5. Arendt J. Melatonin and human rhythms. Chronobiol Int. 2006;23(1-2):21–37. http://dx.doi.org/10.1080/07420520500464361.
6. Moller M, Baeres FM. The anatomy and innervation of the mammalian pineal gland. Cell Tissue Res. 2002;309(1):139–50. http://dx.doi.org/10.1007/s00441-002-0580-5.

7. Blask DE. Melatonin, sleep disturbance and cancer risk. Sleep Med Rev. 2009;13(4):257–64. http://dx.doi.org/10.1016/j.smrv.2008.07.007.

8. Blask DE, Hill SM, Dauchy RT, Xiang S, Yuan L, Duplessis T, Mao L, Dauchy E, Sauer LA. Circadian regulation of molecular, dietary, and metabolic signaling mechanisms of human breast cancer growth by the nocturnal melatonin signal and the consequences of its disruption by light at night. J Pineal Res. 2011;51(3):259–69. http://dx.doi.org/10.1111/j.1600-079X.2011.00888.x.

9. Arendt J, Skene DJ. Melatonin as a chronobiotic. Sleep Med Rev. 2005;9(1):25–39. http://dx.doi.org/10.1016/j.smrv.2004.05.002.

10. Filipski E, Delaunay F, King VM, Wu MW, Claustrat B, Grechez-Cassiau A, et al. Effects of chronic jet lag on tumor progression in mice. Cancer Res. 2004;64(21):7879–85. http://dx.doi.org/10.1158/0008-5472.CAN-04-0674.

11. Mirick DK, Davis S. Melatonin as a biomarker of circadian dysregulation. Cancer Epidemiol.Biomarkers Prev. 2008;17(12):3306–13. http://dx.doi.org/10.1158/1055-9965.EPI-08-0605.

12. Schernhammer ES, Hankinson SE. Urinary melatonin levels and breast cancer risk. J Natl Cancer Inst. 2005;97(14):1084–7. http://dx.doi.org/10.1093/jnci/dji190.

13. Schernhammer ES, Berrino F, Krogh V, Secreto G, Micheli A, Venturelli E, et al. Urinary 6-sulfatoxymelatonin levels and risk of breast cancer in postmenopausal women. J NatlCancer Inst. 2008;100(12):898–905. http://dx.doi.org/10.1093/jnci/djn171.

14. Schernhammer ES, Hankinson SE. Urinary melatonin levels and postmenopausal breast cancer risk in the Nurses' Health Study cohort. Cancer Epidemiol Biomarkers Prev. 2009;18(1):74–9. http://dx.doi.org/10.1158/1055-9965.EPI-08-0637.

15. Schernhammer ES, Berrino F, Krogh V, Secreto G, Micheli A, Venturelli E, et al. Urinary 6-Sulphatoxymelatonin levels and risk of breast cancer in premenopausal women: the ORDET cohort. Cancer Epidemiol Biomarkers Prev. 2010;19(3):729–37. http://dx.doi.org/10.1158/1055-9965.EPI-09-1229.

16. Travis RC, Allen DS, Fentiman IS, Key TJ. Melatonin and breast cancer: a prospective study. J Natl Cancer Inst. 2004;96(6):475–82. http://dx.doi.org/10.1093/jnci/djh077.

17. Marie HA, Helene GA, Hansen J. Diurnal urinary 6-sulfatoxymelatonin levels among healthy Danish nurses during work and leisure time. Chronobiol Int. 2006;23(6):1203–15. http://dx.doi.org/10.1080/07420520601100955.

18. Burch JB, Yost MG, Johnson W, Allen E. Melatonin, sleep, and shift work adaptation. J Occup Environ Med. 2005;47(9):893–901. http://dx.doi.org/10.1097/01.jom.0000177336.21147.9f.

19. Gibbs M, Hampton S, Morgan L, Arendt J. Predicting circadian response to abrupt phase shift: 6-sulphatoxymelatonin rhythms in rotating shift workers offshore. J Biol Rhythms. 2007;22(4):368–70. http://dx.doi.org/10.1177/0748730407302843.

20. Grundy A, Sanchez M, Richardson H, Tranmer J, Borugian M, Graham CH, Aronson KJ. Light intensity exposure, sleep duration, physical activity, and biomarkers of melatonin among rotating shift nurses. Chronobiol Int. 2009;26(7):1443–61. http://dx.doi.org/10.3109/07420520903399987.

21. Grundy A, Tranmer J, Richardson H, Graham CH, Aronson KJ. The Influence of Light at Night Exposure on Melatonin Levels among Canadian Rotating Shift Nurses. Cancer Epidemiol Biomarkers Prev. 2011;20(11):2404–12. http://dx.doi.org/10.1158/1055-9965.EPI-11-0427.

22. Gooley JJ, Rajaratnam SM, Brainard GC, Kronauer RE, Czeisler CA, Lockley SW. Spectral responses of the human circadian system depend on the irradiance and duration of exposure to light. Sci Transl Med. 2010;2(31):31–3.

23. Hansen J. Increased breast cancer risk among women who work predominantly at night. Epidemiology. 2001;12(1):74–7. http://dx.doi.org/10.1097/00001648-200101000-00013.

24. Lie JA, Roessink J, Kjaerheim K. Breast cancer and night work among Norwegian nurses. Cancer Causes Control. 2006;17(1):39–44. http://dx.doi.org/10.1007/s10552-005-3639-2.

25. Schernhammer ES, Kroenke CH, Laden F, Hankinson SE. Night work and risk of breast cancer. Epidemiology. 2006;17(1):108–11. http://dx.doi.org/10.1097/01.ede.0000190539.03500.c1.

26. Schernhammer ES, Laden F, Speizer FE, Willett WC, Hunter DJ, Kawachi I, Colditz GA. Rotating night shifts and risk of breast cancer in women participating in the nurses' health study. J Natl Cancer Inst. 2001;93(20):1563–8. http://dx.doi.org/10.1093/jnci/93.20.1563.

27. Tynes T, Hannevik M, Andersen A, Vistnes AI, Haldorsen T. Incidence of breast cancer in Norwegian female radio and telegraph operators. Cancer Causes Control. 1996;7(2):197–204. http://dx.doi.org/10.1007/BF00051295.

28. Davis S, Mirick DK, Stevens RG. Night shift work, light at night, and risk of breast cancer. J Natl Cancer Inst. 2001;93(20):1557–62. http://dx.doi.org/10.1093/jnci/93.20.1557.

29. O'Leary ES, Schoenfeld ER, Stevens RG, Kabat GC, Henderson K, Grimson R, et al. Shift work, light at night, and breast cancer on Long Island, New York. Am J Epidemiol. 2006;164(4):358–66. http://dx.doi.org/10.1093/aje/kwj211.

30. Schwartzbaum J, Ahlbom A, Feychting M. Cohort study of cancer risk among male and female shift workers. Scand J Work Environ Health. 2007;33(5):336–43. http://dx.doi.org/10.5271/sjweh.1150.

31. Pesch B, Harth V, Rabstein S, Baisch C, Schiffermann M, Pallapies D, et al. Night work and breast cancer - results from the German GENICA study. Scand J Work Environ Health.2010;36(2):134–41. http://dx.doi.org/10.5271/sjweh.2890.

32. Lie JA, Kjuus H, Zienolddiny S, Haugen A, Stevens RG, Kjaerheim K. Night work and breast cancer risk among Norwegian nurses: assessment by different exposure metrics. Am J Epidemiol. 2011;173(11):1272–9. http://dx.doi.org/10.1093/aje/kwr014.

33. Hansen J, Stevens RG. Case-control study of shift-work and breast cancer risk in Danish nurses: Impact of shift systems.

Eur J Cancer. 2011.

34. Pronk A, Ji BT, Shu XO, Xue S, Yang G, Li HL, et al. Night-shift work and breast cancer risk in a cohort of Chinese women. Am J Epidemiol. 2010;171(9):953–9. http://dx.doi.org/10.1093/aje/kwq029.

35. Fritschi L, Glass DC, Heyworth JS, Aronson K, Girschik J, Boyle T, et al. Hypotheses for mechanisms linking shift work and cancer. Med Hypotheses. 2011;77(3):430–6. http://dx.doi.org/10.1016/j.mehy.2011.06.002.

36. Driscoll TR, Grunstein RR, Rogers NL. A systematic review of the neurobehavioural and physiological effects of shift work systems. Sleep Med Rev. 2007;11(3):179–94. http://dx.doi.org/10.1016/j.smrv.2006.11.001.

37. Sallinen M, Kecklund G. Shift work, sleep, and sleepiness - differences between shift schedules and systems. Scand J Work Environ Health. 2010;36(2):121–33. http://dx.doi.org/10.5271/sjweh.2900.

38. Stevens RG, Hansen J, Costa G, Haus E, Kauppinen T, Aronson KJ, et al. Considerations of circadian impact for defining 'shift work' in cancer studies: IARC Working Group Report. Occup Environ Med. 2011;68(2):154–62.

39. Haus E, Smolensky M. Biological clocks and shift work: circadian dysregulation and potential long-term effects. Cancer Causes Control. 2006;17(4):489–500. http://dx.doi.org/10.1007/s10552-005-9015-4.

40. Stevens RG, Blask DE, Brainard GC, Hansen J, Lockley SW, Provencio I, et al. Meeting report: the role of environmental lighting and circadian disruption in cancer and other diseases. Environ Health Perspect. 2007;115(9):1357–62. http://dx.doi.org/10.1289/ehp.10200.

41. Erren TC, Pape HG, Piekarski C, Reiter RJ. Not all shifts are equal: it's time for comprehensive exposure metrics in chronodisruption research. Cancer Res. 2008;68(10):4011. http://dx.doi.org/10.1158/0008-5472.CAN-08-0279.

42. Härmä M, Hakola T, Kandolin I, Sallinen M, Vahtera J, Anne B, Mutanen P. A controlled intervention study on the effects of a very rapidly forward rotating shift system on sleep-wakefulness and well-being among young and elderly shift workers. Int J Psychophysiol. 2006;59(1):70–9. http://dx.doi.org/10.1016/j.ijpsycho.2005.08.005.

43. Härmä MI, Hakola T, Åkerstedt T, Laitinen JT. Age and adjustment to night work. Occup Environ Med. 1994;51(8):568–73. http://dx.doi.org/10.1136/oem.51.8.568.

44. Brainard GC, Hanifin JP, Greeson JM, Byrne B, Glickman G, Gerner E, Rollag MD. Action spectrum for melatonin regulation in humans: evidence for a novel circadian photoreceptor. J Neurosci. 2001;21(16):6405–12.

45. Thapan K, Arendt J, Skene DJ. An action spectrum for melatonin suppression: evidence for a novel non-rod, non-cone photoreceptor system in humans. J Physiol. 2001;535(Pt 1):261–7. http://dx.doi.org/10.1111/j.1469-7793.2001.t01-1-00261.x.

46. Lowden A, Åkerstedt T, Wibom R. Suppression of sleepiness and melatonin by bright light exposure during breaks in night work. J Sleep Res.2004;13(1):37-43. http://dx.doi.org/10.1046/j.1365-2869.2003.00381.x.

47. Khalsa SB, Jewett ME, Cajochen C, Czeisler CA. A phase response curve to single bright light pulses in human subjects. J Physiol. 2003;549:945–52. http://dx.doi.org/10.1113/jphysiol.2003.040477.

48. Sauer LA, Blask DE, Dauchy RT. Dietary factors and growth and metabolism in experimental tumors. J Nutr Biochem. 2007;18(10):637–49. http://dx.doi.org/10.1016/j.jnutbio.2006.12.009.

49. Garde AH, Hansen AM, Hansen J. Sleep length and quality, sleepiness and urinary melatonin among healthy Danish nurses with shift work during work and leisure time. Int Arch Occup Environ Health. 2009;82(10):1219–28. http://dx.doi.org/10.1007/s00420-009-0419-4.

50. Kakizaki M, Kuriyama S, Sone T, Ohmori-Matsuda K, Hozawa A, Nakaya N, et al. Sleep duration and the risk of breast cancer: the Ohsaki Cohort Study. Br J Cancer. 2008;99(9):1502–5. http://dx.doi.org/10.1038/sj.bjc.6604684.

51. Saksvik IB, Bjorvatn B, Hetland H, Sandal GM, Pallesen S. Individual differences in tolerance to shift work--a systematic review. Sleep Med Rev. 2011;15(4):221–35. http://dx.doi.org/10.1016/j.smrv.2010.07.002.

52. Stevens RG. Circadian disruption and breast cancer: from melatonin to clock genes. Epidemiology. 2005;16(2):254–8. http://dx.doi.org/10.1097/01.ede.0000152525.21924.54.

53. De Gelder R, Draisma G, Heijnsdijk EA, de Koning HJ. Population-based mammography screening below age 50: balancing radiation-induced vs prevented breast cancer deaths. Br J Cancer. 2011;104(7):1214–20. http://dx.doi.org/10.1038/bjc.2011.67.

54. Bonde JP, Andersen JH, Frost P, Kaergaard A, Kolstad HA, Thulstrup AM. [Health examinations in connection with night work]. Ugeskr.Laeger. 2007;169(21):2005–7.

55. Boulware LE, Barnes GJ, Wilson RF, Phillips K, Maynor K, Hwang C, et al. Value of the periodic health evaluation. Evid Rep Technol Assess.(Full.Rep.). 2006;(136):1–134.

56. Marshall KG. Prevention. How much harm? How much benefit? 3. Physical, psychological and social harm. CMAJ. 1996;155(2):169–76.

57. Sahar S, Sassone-Corsi P. Circadian clock and breast cancer: a molecular link. Cell Cycle. 2007;6(11):1329–31. http://dx.doi.org/10.4161/cc.6.11.4295.

58. Lissoni P. Is there a role for melatonin in supportive care? Support Care Cancer. 2002;10(2):110–6. http://dx.doi.org/10.1007/s005200100281.

59. Breast cancer on the night shift. Lancet. 2009;373(9669):1054. http://dx.doi.org/10.1016/S0140-6736(09)60626-7.

60. Zhu Y, Stevens RG, Hoffman AE, Tjonneland A, Vogel UB, Zheng T, Hansen J. Epigenetic impact of long-term shift work: pilot evidence from circadian genes and whole-genome methylation analysis. Chronobiol Int. 2011;28(10):852–61. http://dx.doi.org/10.3109/07420528.2011.618896.

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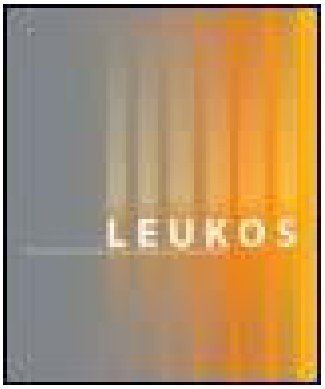

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Comparison and Correction of the Light Sensor Output from 48 Wearable Light Exposure Devices by Using a Side-by-Side Field Calibration Method

Jakob Markvart[a], Åse Marie Hansen[b] & Jens Christoffersen[c]
[a] Danish Building Research Institute, Aalborg University, Copenhagen, Denmark
[b] Department of Public Health, University of Copenhagen, Copenhagen, Denmark
[c] VELUX A/S, Hørsholm, Denmark
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Jakob Markvart[1], Åse Marie Hansen[2], and Jens Christoffersen[3]
[1]Danish Building Research Institute, Aalborg University, Copenhagen, Denmark
[2]Department of Public Health, University of Copenhagen, Copenhagen, Denmark
[3]VELUX A/S, Hørsholm, Denmark

ABSTRACT Measurement of personal light exposures and activity has gained popularity in studies of the circadian rhythm and its effects on human health. Calibration of a batch of measuring devices may be needed, especially before initiating interventional studies, but manufactory calibration of devices before every initiated study is costly for the researcher and therefore often left out. Still, knowledge of inter-equipment variability is essential and seldom provided by the manufactory. The aim of the present study was to develop and test a method for field calibration of Actiwatch Spectrum devices. We tested 48 Actiwatch devices side by side under various light sources and present the red, green, blue, and white light response variability among the Actiwatches. The influence of different spatial and spectral light environments on the white light response when compared with the output from a calibrated photometer is discussed. In agreement with previous studies by Price and others [2012] and Figueiro and others [2013], we confirm the devices' white light responses to be highly dependent on both the spatial and the spectral composition of the light. The white light response represents photopic illuminance only to a minor degree and light source-specific calibration may therefore be needed in some cases. Moreover, light responses were found to vary between devices by up to 60%. Implications are that the results of light effects on health issues in studies using Actiwatches are blurred by the equipment variability. To compensate for inter-equipment variability we stress the need for a field calibration procedure. When light exposure devices of lower grade quality are used in spectrally and spatially changing light environments, daylight from a diffused overcast sky is suggested to be used for side-by-side calibration of Actiwatches and similar personal light exposure devices. We suggest that the calibration methods presented can be used for calibration of other practical field devices, with respect to the various sensors already on the market and devices that will be introduced in the future.

KEYWORDS spectral power distribution (SPD), RGB light, scotopic vision, photopic vision, photopic illuminance, illuminance meter

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Address correspondence to Jakob Markvart, Danish Building Research Institute, Aalborg University, A.C. Meyers Vænge 15, DK-2450 Copenhagen SV, Denmark. E-mail: jam@sbi.aau.dk

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1. INTRODUCTION

Many different measuring devices for personal light exposure are used in the field. These devices often report photopic illuminance in lux, but the devices seldom meet the requirements of laboratory photometers [Figueiro and others 2013]. Often, the sensors of light exposure devices are not cosine corrected and may not perfectly follow the photopic luminous efficiency function, $V(\lambda)$, as previous work on Philips Respironics Actiwatch Spectrum™ (Philips Healthcare, Best, Netherlands) devices has demonstrated [Figueiro and others 2013; Price and others 2012]. The work of Price and others [2012] made it clear that the specific location, orientation, and shape of light sensors in a measuring device determine the sensors' field of view, thus influencing the response. Although the device dimensions and sensor location may only slightly differ between individual devices, small deviations may have a great impact on the light registration dependent on the present spectral and spatial light conditions. Because of variation between light exposure devices in terms of spectral and spatial light responses, the light intensities being measured depend on the particular light measuring device and the actual light conditions, which are seldom stable. When used in the field, the ever-changing spatial and spectral light condition has consequences for the light measurements of personal light exposure devices. The impact of this is important for comparative studies and stresses the need for high standards of the light sensors used or in-depth knowledge of the lower quality devices used.

When measuring light at a fixed location where the major contribution of light comes from one stable light source, the use of low-quality broad-spectrum light sensors will provide useful measurements of, for example, photopic illuminance if the sensor has been calibrated against a light source like the one at the location. This is called "source-specific calibration." In contrast, when used in continuously changing spatial and spectral light conditions, how do we deal with the broad-spectrum light sensor measurements?

Knowledge of humans' daily exposure to light is still limited [Veitch and Galasiu 2012]. Numerous light sensors of varying quality are used on the market, and devices especially used and designed to measure personal light exposure have various designs. Some are to be fixed on the wrist, whereas others are fixed on the forehead [Figueiro and others 2013; Hubalek and others 2010; Rea 2006]. Exposure devices, like, for example, Actiwatch Spectrum devices, are also able to measure activity [Price and others 2012]. Devices worn on the wrist are more discreet to wear than those fixed on the forehead. The devices fixed on the forehead measure the light coming from the same direction as the eyes, thus being more relevant in specific cases, where discreetness is not required [Rea 2006].

There is a great difference in the spectrum of white light sources like, for example, fluorescent and tungsten halogen light (Fig. 1). Inside buildings there is often a mix of light from different sources, including daylight. Colored light or RGB light is now becoming increasingly common. It offers the advantages of obtaining better color rendering [Jost-Boissard and others 2009] or the possibility of mixing light of different colors or diminishing the intensity of certain wavelength bands with the aim of, for example, enhancing nurses' ability to see veins during blood sampling. Moreover, colors have been shown to be connected with emotions, and the same can be assumed to apply to the color of light [Rautkyla and others 2011]. Therefore, and in addition to measuring illuminance, some knowledge of the spectral composition of light exposure is important in studies of colour impacts.

The spectral sensitivity of the R, G, and B sensor; directional response; linearity of the sensor response; and the use of diffusers to enhance the directional response of Actiwatch Spectrum devices was published earlier [Figueiro and others 2013; Price and others 2012]. Price and others [2012] found that the directional response is far from close to a perfect cosine response, with cosine response errors of approximately 30%–50% in the horizontal plane and approximately 60%–65% in the vertical plane.

Ideally for comparative studies, all sensors should have the same defined standard response pattern as if they were cosine corrected and had a spectral sensitivity matching the response of interests like $V(\lambda)$. However, new sensors with different specifications are continuously introduced on the market, and therefore an easy-to-perform standard calibration procedure in the field is needed to limit the bias of equipment variability.

The aim of the present study was to develop and test a method for calibration of Actiwatch devices in field studies, with respect to the various sensors already on the market and devices that will be introduced in future. The Actiwatch white light output (W_{Acti} light) is reported as being photopic illuminance measured in lux. However, the W_{Acti} light is derived from a not published function of the light received by the Actiwatch sensor measuring light in three wavelength bands named after their associated color perceptions like red (R light), green (G light), and blue (B light). The Actiwatch sensor's relative response per wavelength has been reported for the W_{Acti}, R, G,

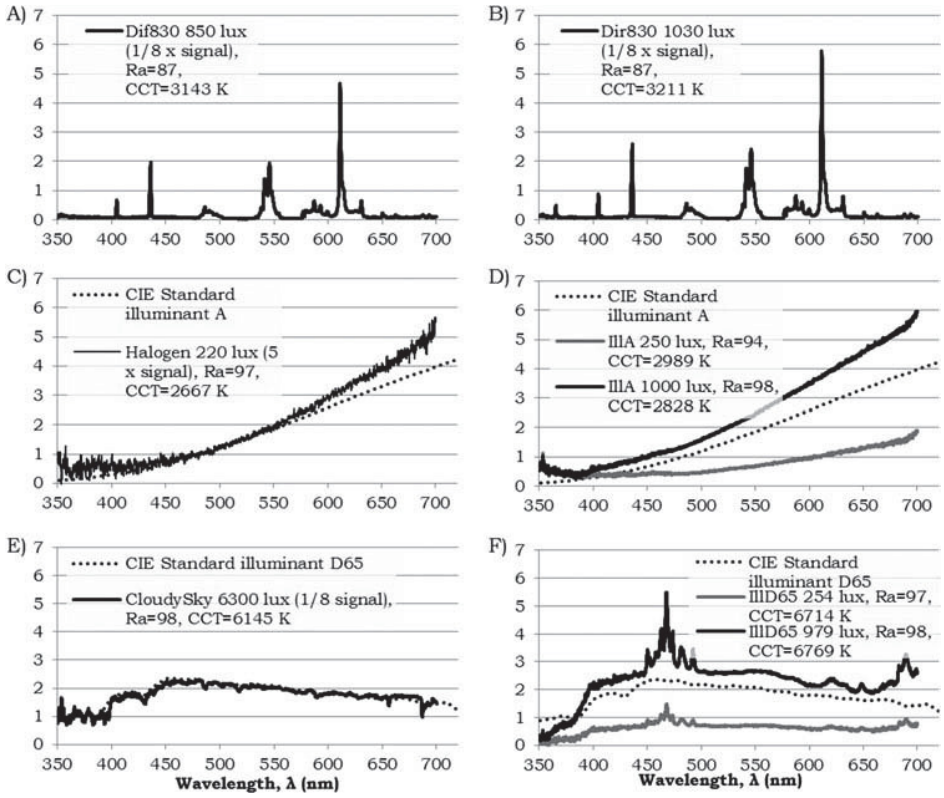

Fig. 1 **Relative spectral composition of the light used for the calibration tests, including (A) diffused fluorescent light (Dif830); (B) direct fluorescent light (Dir830); (C) tungsten halogen (Halogen); and (D) approximate standard illuminant A (IllA), at two light intensities; (E) overcast sky conditions (CloudySky); and (F) approximate standard illuminant D65, at two light intensities. Included in (C) and (D) is the CIE-defined standard illuminant A and in (E) and (F) the CIE defined standard illuminant D65. When indicated in parentheses, the signal responses are corrected linearly to fit the relative scale (*y* axis).**

and B light [Figueiro and others 2013; Price and others 2012]. A defined spectral sensitivity of sensors suggests that when measuring under the same spectral and spatial light conditions, the relationships between the R, G, and B light versus W_{Acti} light should ideally be the same regardless of the particular Actiwatch device used. Moreover, it was presumed that the sensor response was linear with increased intensity. These were the premises when trying to find an easily applicable way to calibrate our Actiwatches responses.

2. METHODS

In a large field study initiated in 2011, the overall objective was to investigate whether the light environment for indoor work and night work has health consequences; for example, to evaluate whether high light exposure at night during night-shift work increases the risk of getting breast cancer. For this purpose, we bought 50 Actiwatch Spectrum devices. The choice was made based on a need for the device to be affordable in order to purchase the numbers needed for the field study, commercially available, discreet to wear, and able to measure both activity and photopic illuminance. In addition, we found it attractive that the Actiwatches were able to measure the R, G, and B spectral characteristics of the light. We examined whether there was predictability and similarity in the RGB and W_{Acti} light responses of 48 Actiwatches (two devices were lost during a field experiment), when measuring the light from typical white light sources.

2.1. Actiwatch Configuring and Management

To configure the Actiwatches for measurements, we used the Actiwatch Communication and Sleep Analysis Software: Respironics Actiware version 5.71.0 (Philips Healthcare, Best, the Netherlands). For the various calibration tests, all Actiwatches were set to log measurements of W_{Acti} light; R, G, and B light; and activity every 15 seconds (epoch = 15 seconds) starting from a fixed point in time. The battery level of Actiwatches was given by the software and varied from "full" to "battery replacement required." Therefore, a test was performed ensuring that

the battery status did not affect the results. The software was also used to retrieve data from the Actiwatches and to create .csv-files for further processing. The Actiwatches are named by serial number.

2.2. Correction Values and Lighting Test Schemes

We wanted to determine the extent of the deviation in the individual devices' light measurement in comparison with that of the other measuring devices; that is, to find one correction value (C_{VAL} = measured value/expected value) of the particular devices' measurement. The correction values used and presented are the least-squares regression inclination value; that is, the reciprocal of the often used multiplicative correction factor. A device with a correction value (C_{VAL}) above one thus measures values too high in relation to the reference sensor photopic illuminance and vice versa, and the percentage deviation can be directly transcribed.

A setup with one light scenario for testing all devices at the same time is referred to in the following as a calibration test. The difference in the average C_{VALs} between different selected light environments using standard light sources was examined.

2.2.1. Light response offset test in complete darkness

An offset test in complete darkness was performed to find the W_{Acti}, R, G, and B light average offset response of the Actiwatches. We used an 8-hour period to calculate the average response, considered to be close to an average sleeping period during one day. The offset test was repeated four times.

2.2.2. Batch of devices being calibrated simultaneously under stable light sources

Several calibration tests were completed under various stable light sources including tungsten halogen light (Test: Halogen, Halogen PAR30 TECH, 75W, General Electric, Fairfield, CT, USA) and fluorescent tube light (4 × Philips Master TL5 HE, 14W/830, Philips Lighting, Pila, Poland). Tests were made in a large and blacked-out room under otherwise stable physical conditions. Two different calibration tests with fluorescent light were performed: Fluorescent light directly received from the light tubes and light being redirected in a diffuse manner, referred to as Dir830 and Dif830, respectively. In Dif830 the light was diffused by a 3-mm frosted polycarbonate plate (PLEXIGLAS, the original from Röhm, Germany), placed 1 cm above the Actiwatches underneath the light source. The distance from the halogen and fluorescent light sources to the Actiwatches was 1.0 m. This distance resulted in a visually even light distribution in the field of the placement of the Actiwatches. Placed next to the Actiwatches were the cosine-corrected detector of a newly purchased reference photometer (Hagner EC1-X, Instr. Nr. 54211, B. Hagner AB, Solna, Sweden) and a cosine corrected detector (CC-3-UV-S, Ocean Optics, Inc., Dunedin, FL, USA) connected to an Ocean Optics HR4000 spectrometer (Ocean Optics, Inc.). The Hagner EC1-X reference lux sensor used was checked in our own lab and matched the response of another newly calibrated reference lux sensor (LMT Photometer B510). The spectrometer was controlled by the software SpectraSuite (SpectraSuite, Spectroscopy Software, Ocean Optics, Inc.). The spectrometer measured the spectrum under which the calibration tests were performed.

2.2.3. Batch of devices being calibrated simultaneously under open sky conditions

Tests under open sky conditions were performed under both a sunny and an overcast sky. The Actiwatches were placed perpendicular to the direction to the sun at noon on a building rooftop in Copenhagen (coordinates: 55.650619, 12.542481), on November 1 and 5, 2013. The test under overcast sky conditions is referred to as CloudySky.

2.2.4. Repeated measurements

The Actiwatches were randomly placed side by side and fixed using a Velcro mounting solution for easy and random rearranging of the Actiwatches below all light sources. At every random arrangement, the Actiwatches were placed side by side in four rows and with the same orientation.

Average C_{VALs} were based on three to eight calibration tests (repetitions) using one particular type of light scenario (Figs. 1A–1C and 1E) and with a new random arrangement of the Actiwatches for each test. To make sure that the time of data logging of the Actiwatches matched the manually transcribed lux readout, a covering black cloth was used, and uncovering and covering the devices indicated the start and end of measurements. For every Actiwatch and calibration test, one C_{VAL} was calculated using an average value based on eight Actiwatch

readout points in time—that is, data during 2 minutes—divided by the mean of 8 corresponding-in-time lux values measured by the reference illuminance sensor. This was done in order to level out sensor noise (electrical noise).

The measured R, G, and B light response per Actiwatch was divided by the mean R, G, and B light response, respectively, for the particular calibration test.

2.2.5. Tests at certified calibration test facility

In addition to testing the Actiwatches side by side simultaneously, calibration tests were performed at a certified calibration test facility at Delta (Venlighedsvej 4, DK-2970 Hoersholm, Denmark). Every Actiwatch was alternately placed for 90 seconds both in a collimated illuminant A approximate light source (IllA) and a D65 approximate daylight source (IlID65) at two light intensities of approximately 250 and 1000 lux.

The IlID65 light source was an Osram XBO Xenon Short Arc lamp of 150 W, with a combination of one Schott type LB80, 1.0-mm-thick prefilter and a UV 34, 2.5-mm-thick prefilter. To obtain 250 lux, we further mounted a T0.25 neutral density (ND) filter to reduce the light intensity. This was fitted in an Oriel lamp housing with an adjustable collimating lens used to fine-tune the intensity in the point where the measurement took place. The correlated color temperature was measured to be 6714 K at 250 lux and 6769 K at 1000 lux, respectively.

The IllA light source was a Philips 12V H4 halogen fitted in a lamp housing with a 4.0-mm opal diffuser. The IllA intensity was controlled by metal leaf shutters between the light source and the diffuser. For IllA, the correlated color temperature was measured to be 2989 K at 250 lux and 2828 K at 1000 lux, respectively.

Both lighting systems were fed from a stable DC supply. The spectra under which the calibration tests where made are shown in Figs. 1D and 1F.

We measured illuminance with an LMT photometer with associated detector (light-sensitive surface diameter ø = 30 mm) calibrated and traceable to the Physikalisch-Technische Bundesanstalt (Braunschweig, Germany) and National Physical Laboratory (Teddington, UK). Illuminance was measured at the same position as for the placement of the Actiwatches 1.0 m from the light source.

Correlation between the average W_{Acti} light and the average R, G, and B light for IlID65 and IllA was made in the same way as for Dif830, Dir830, Halogen, and CloudySky.

Average W_{Acti} and R, G, and B light C_{VALs} for the two light intensities for IlID65 and IllA, respectively, were calculated per Actiwatch. These C_{VALs} were used in the comparisons of calibration methods.

2.2.6. Comparing different calibration methods

The average W_{Acti} and R, G, and B light C_{VAL} for the two light intensities for IlID65 and IllA, respectively, was considered to be the result of a standard calibration procedure or method for calibration of devices. This result was compared with the result of the alternative method for calibration, measuring the light simultaneously with all of the devices (repeated measurements of an Actiwatch batch of devices). We compared the C_{VAL} test result of the light scenario that corresponded the most with the spectrum of IllA and IlID65, thus comparing Halogen versus IllA and CloudySky versus IlID65.

The following plots were made: (A) average W_{Acti} light C_{VALs} for Halogen and IllA; (B) average R, G, and B light C_{VALs} for Halogen and IllA; (C) average W_{Acti} light C_{VALs} for CloudySky and IlID65; and (D) average R, G, and B light C_{VALs} for CloudySky and IlID65. The slope and intercept of the associations and their confidence intervals were estimated using a linear functional model and Deming regression [Deal and others 2009; Mandel and Lashof 1974].

2.3. Comparing Two Sets of Measurements—Deming Regression

Ordinary least squares regression cannot be used in the setting where two sets of measurements are compared, because it assumes that only one variable has a measurement error. In order to account for measurement errors in both the independent and dependent variables, we used a functional model and Deming regression, as described by Deal and others [2009]. SAS 9.4 (SAS Institute, Cary, NC) was used for the computation. The Deming regression line of the functional model is estimated by minimizing the sums of squared deviations in both the x and y directions at an angle determined by the ratio of the analytical standard deviations for the two methods. This ratio can be estimated if multiple measurements are made with each method. Alternatively, if only one measurement is made with each method, it can be considered equal to one [Deal and others 2009; Mandel and Lashof 1974]. We used the functional model $E(Yi) = b * E(Xi) + a$, where b denotes the slope and a denotes the intercept and found the relationship and

confidence intervals between the W_{Acti} light and the R, G, and B light responses per light scenario. Moreover, we correlated the average W_{Acti} light C_{VALs} and the average R, G, and B C_{VALs}, respectively, of Halogen versus IllA and CloudySky versus IllA, thus correlating the average C_{VALs} found using a standard calibration method against the average C_{VALs} of the alternative method of calibration.

The software IBM SPSS statistics was used for the computation of statistical estimates of C_{VAL} (average C_{VAL}) using the mixed model procedure.

3. RESULTS

3.1. Lighting Scenarios, Tests, and Effects

The different white light scenarios were characterized by spectrum and illuminance (Fig. 1).

In addition to testing in an illuminant A and illuminant D65 approximate light sources, a fluorescent discharge light source was used with and without a light-diffusing polycarbonate plate in front. The plate resulted in differences in the spatial light distributions between Dif830 and Dir830. The spectra of Dif830 and Dir830 were similar, apart from the small peak around 365 nm appearing in the Dir830 measured spectrum and not in the spectrum of Dif830 (Figs. 1A and 1B).

The distance from each Actiwatch to the light source differed slightly when testing under halogen and fluorescent light sources. Therefore, the light received by the Actiwatches during each calibration test varied (lux variations of approximately 10% for the electrical light sources). Repetitions with random placement of the devices were executed and found to be needed to even out the variations. Thus, every calibration test for one light scenario counted as a repetition and equally in the calculation of the average C_{VALs}.

In darkness, the offsets were found not to be a constant value and therefore an 8-hour period was used to calculate the average. The Actiwatches' average W_{Acti} light offset was between 0.0 and 1.1 (Fig. 2).

As for the W_{Acti} light, some variation was found in the R, G, and B light offsets between the Actiwatches (Figs. 2 and 3). The average R, G, and B light offset of the Actiwatches ranged between 0.000 and 0.184 R light units, 0.000 and 0.088 G light units, and 0.000 and 0.038 B light units (Fig. 3).

Dissimilar C_{VALs} were found depending on the light scenario but also depending on the particular Actiwatch used. The difference in the W_{Acti} light C_{VAL} for the Actiwatches is shown in Figs. 4A–4C.

Whereas the two light intensities of IllA resulted in similar C_{VALs}, the light intensities of IllD65 unfortunately did not (Figs. 4B and 4C). The average W_{Acti} light C_{VALs} found per Actiwatch for Dif830 and Dir830 shows some variation regarding how individual Actiwatches perform relative to the other Actiwatches and depending on the particular light scenario (Fig. 4A). The error bars indicate the 95% confidence intervals with the number of tests included: Dir830 $n = 4$ and Dif830 $n = 8$, where n is the number of calibration tests.

Although the number of tests for Dif830 and Dir830 differs, the sizes of confidence intervals do not differ significantly (Fig. 4A). The number of tests was doubled for the Dif830 (compared with Dir830) to explore why some Actiwatches acted unexpectedly in some Dif830 tests and whether this was just a coincidence resulting in larger variations in C_{VALs} found per Actiwatch. The R, G, and B light C_{VALs} were also found to depend on the particular

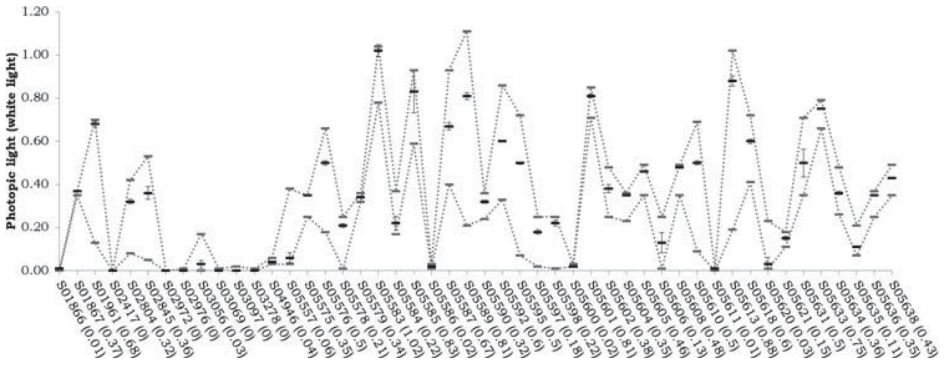

Fig. 2 **White light offset during time of no movement and when Actiwatches are placed in darkness. The white light offset estimate is written in paraphrases after the Actiwatch serial numbers at (the legend) and in the graph indicated with black marks and corresponding standard deviations ($n = 4$; that is, four tests with average white light from 8 hours). The absolute minimum and maximum white light found are indicated by grey marks connected by dashed lines.**

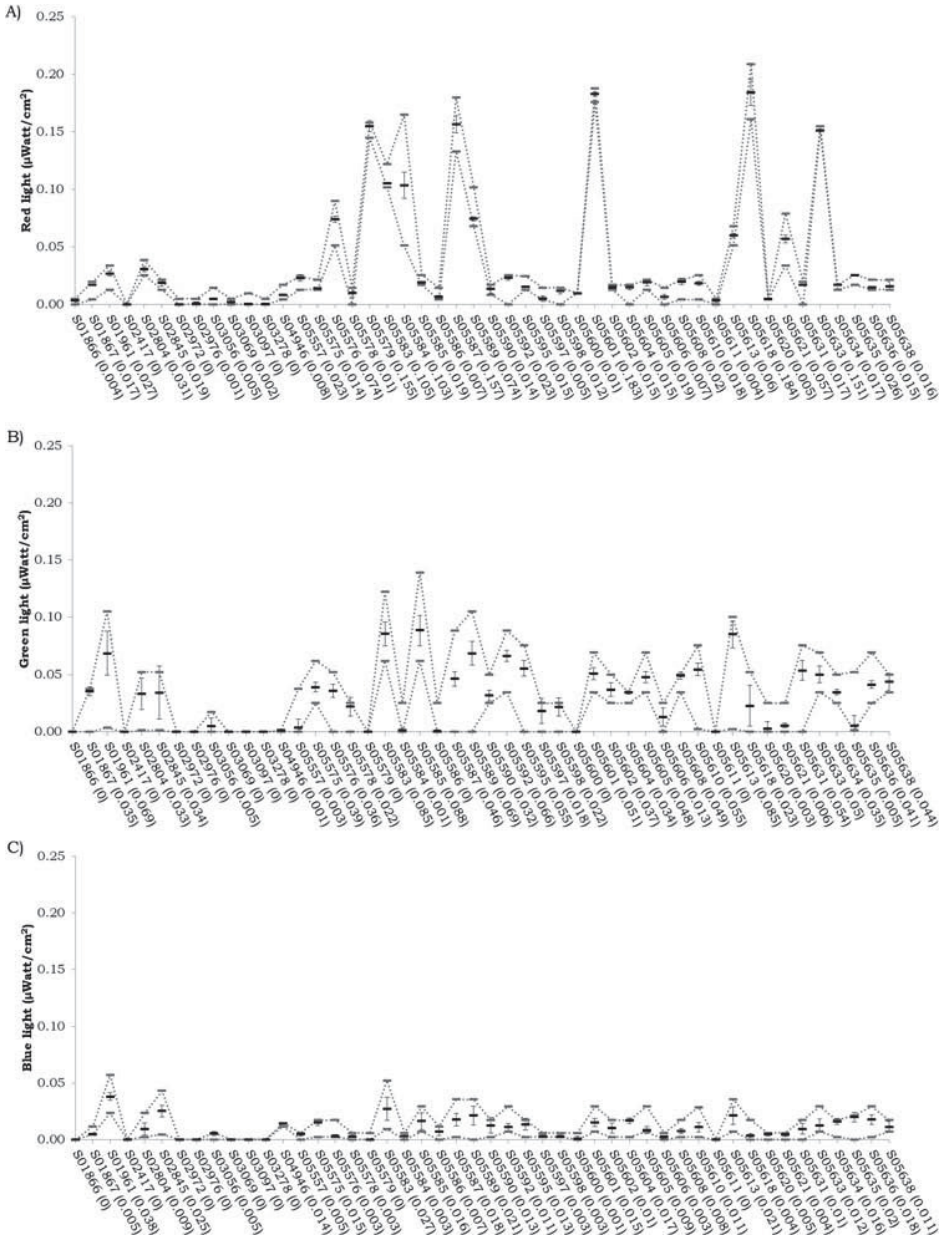

Fig. 3 **Offset of the Actiwatch R, G, and B colors during time when Actiwatches were placed in darkness. The average offset is written in paraphrases after the Actiwatch serial numbers at (the legend) and in the graph indicated with black marks with corresponding standard deviations (n = 4; that is, four tests with average light from 8 hours). The absolute minimum and maximum offset found are indicated by grey marks connected by dashed lines.**

Actiwatch used, but some C_{VAL} results of the Dif830 were also found to deviate from the other lighting scenarios (Fig. 5).

Figure 6A shows a plot of W_{Acti} light vs. R, G, and B light of all of the data from the eight Dif830 tests performed, which revealed one reason for the larger variations in C_{VALs} found for Dif830 tests.

When analyzing the data from the Dif830 tests, several significant and sudden drops in the B light (B-light drops) were registered by several Actiwatches (Fig. 5C), although the light present during the tests was stable. These B-light drops affected all of the light channels (the R, G, B, and W_{Acti} light). Data where B-light drops occurred could easily be distinguished from data where these drops did not occur (Fig. 6A). The data with B-light drops caused a 52% reduction of B light and a 2% reduction of the G light, wheras the R light was increased by 23% (Fig. 6A and Table 1). During the eight Dif830 tests, around 18%

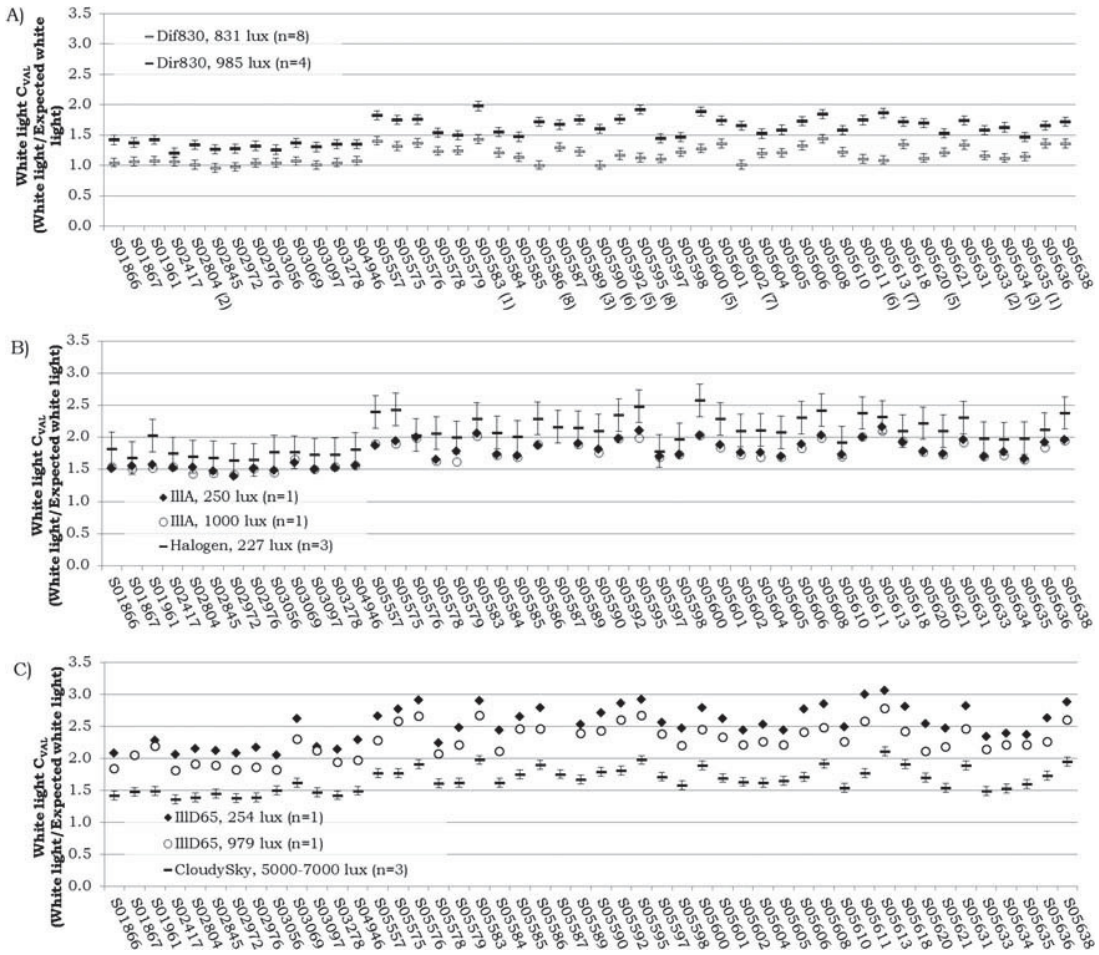

Fig. 4 **Average white light C_{VAL} per Actiwatch for (A) Dif830 ($n = 8$) and Dir830 ($n = 4$); next to the legend in parentheses is written the number of B-light drop incidences during the Dif830 tests, causing the relatively lower C_{VAL}s. (B) Halogen ($n = 3$) and IIIA at two intensities. (C) CloudySky ($n = 3$) and IIID65 at two intensities. The error bars indicate the 95% confidence intervals.**

of data showed a trend with B-light drops, where some Actiwatches were more likely to occasionally measure this (see legend in Fig. 4A).

The change in R, G, and B response relative to the RGB sum was found as a reduction of B (−7.33% points) and G (−1.22% points), which equals the increase in R (8.55% points; Table 1). The changed R, G, and B relationship for the data with B-light drops resulted in lower measured W_{Acti} light and thus a reduced average W_{Acti} light C_{VAL} of 1.02 for (selected) B-light drop data versus an average W_{Acti} light C_{VAL} of 1.21 for those categorized as having no B-light drops. The average W_{Acti} light was 854.5 for B-light drop data being significantly lower than the average W_{Acti} light = 1005.3 for the non-B-light drop data (Table 1). For Actiwatches not having any occurrence of B-light drops in any of the eight Dif830 calibration tests, the average W_{Acti} light C_{VAL} was found to be relatively high, whereas those with increasing number of B-light drops had a relatively low average W_{Acti} light C_{VAL} (Fig. 4A).

The correlation between the color responses and W_{Acti} light clearly revealed the B-light drops (Fig. 6A). The B-light drop occurrence could not be ascertained in the other calibration tests (Figs. 6B–6F).

The correlation between G and W_{Acti} light was found to be much stronger and with smaller standard errors compared to those of both R and B when correlated with W_{Acti} light (Fig. 6). The correlations between the Actiwatch colors and W_{Acti} light, where only one light scenario and intensity was used, resulted in intercepts of the regression lines deviating from 0 (Fig. 6). This was more evident under the electrical light sources.

Table 2 lists the overall average values obtained from the different calibrations. The sum of the color responses showed only minor relation to the W_{Acti} light response (Table 2).

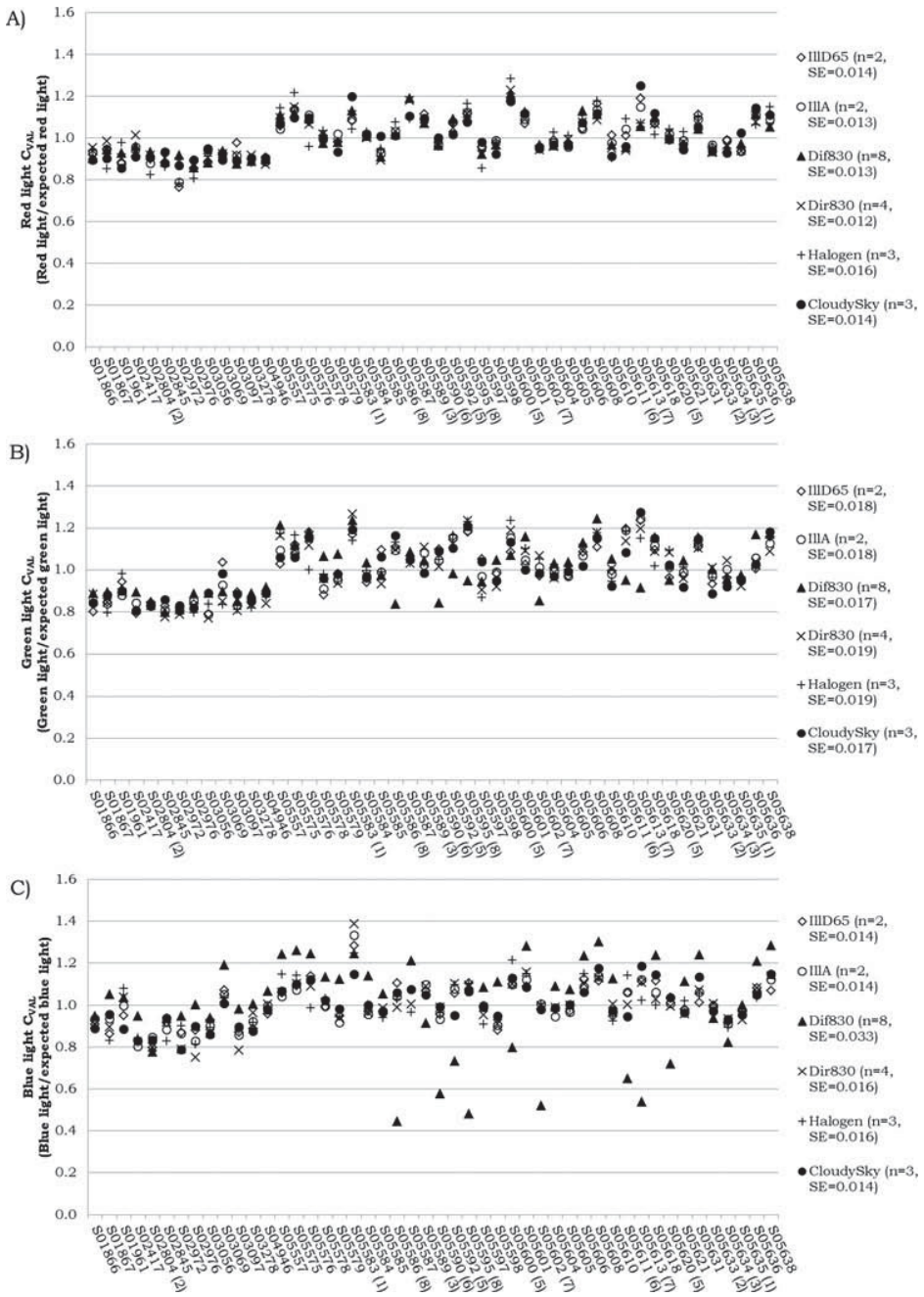

Fig. 5 **The average coloured light response C_{VAL} per Actiwatch for Dif830, Dir830, Halogen, average IIIA of two intensities, CloudySky and average IIID65 of two intensities. (A) R C_{VALs} per Actiwatch. (B) G C_{VALs} per Actiwatch. (C) B C_{VALs} per Actiwatch. The number of calibration tests (n) and SE for the means per light scenario are next to the symbols. Next to the legend in parenthesis is written the amount of B-light drop incidences during the Dif830 tests.**

The G light correlated nicely with the W_{Acti} light, whereas the R and B light did not. Roughly, the G light can be calculated based on measurement of W_{Acti} light and vice versa but only if the light condition is known. The RG and B light versus W_{Acti} light correlation regression slopes differed depending on the light scenario. Therefore, the B and R light responses in particular need individual calibration per Actiwatch. We normalized the R, G, and B light of each individual Actiwatch to the average of all Actiwatches' R, G, and B light response, respectively. This was done for each test and light scenario.

The measurements made using IIlA showed similar C_{VALs} for both of the IIlA intensities (Fig. 4B and Table 2). The levels of C_{VALs} differed for the two IIlD65 intensities

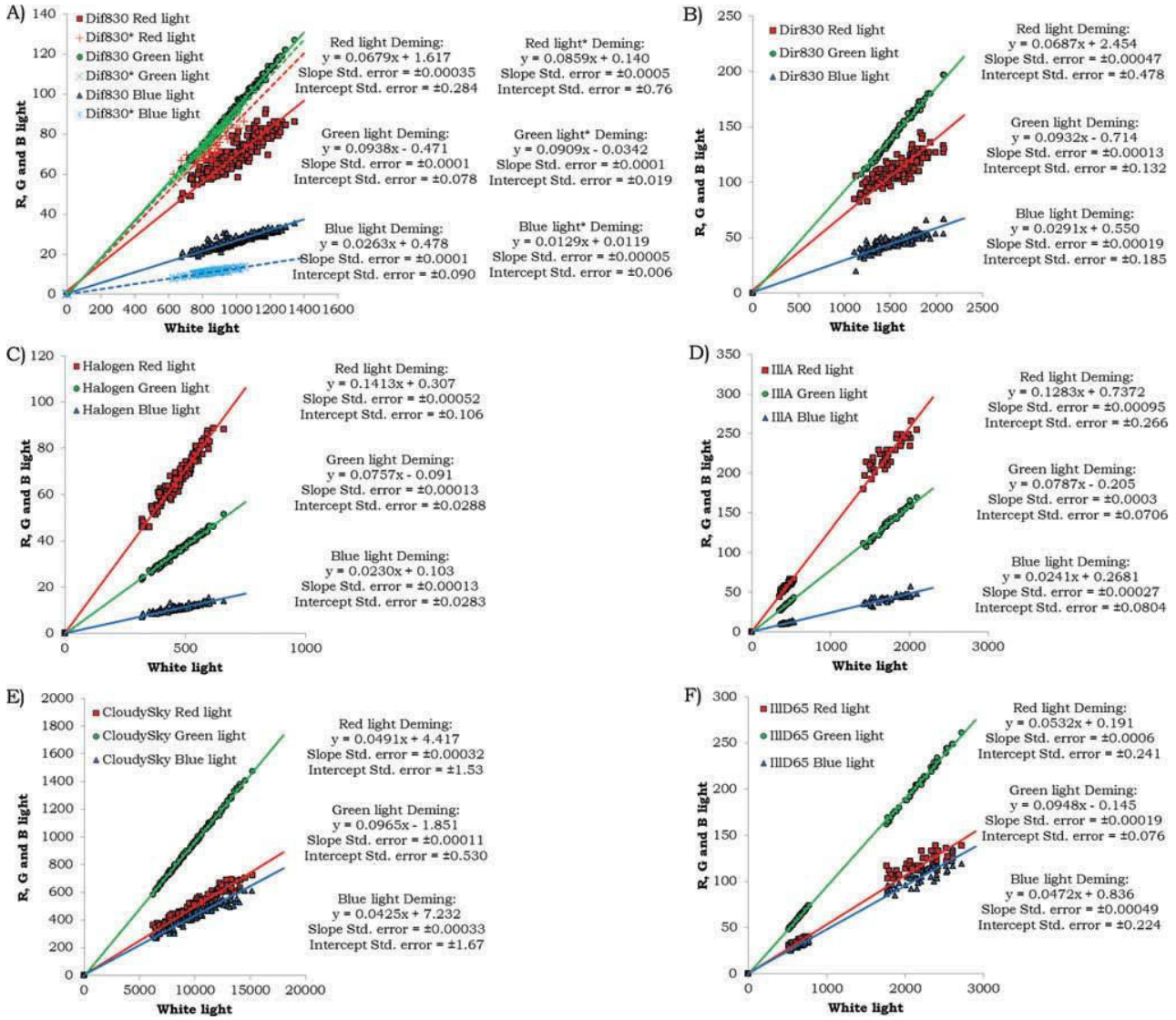

Fig. 6 **Data of white light versus corresponding R, G, and B light from (A) the Dif830, (B) Dir830, (C) Halogen, (D) IIIA, (E) CloudySky, and (F) IIID65 calibration tests. (A) Selected measurements (*) are distinctively different from the rest. During the eight Dif830 tests, 18% of data showed a trend with B-light drops, where some Actiwatches were more likely to measure this occasionally. The slope and intercept of the association and its confidence intervals for the relation between white light and the R, G, and B responses are found using a functional model (Deming regression).**

TABLE 1 **The B-light drop occurrence and its influence on the R, G, and B light relationship and the change in the average RGB sum and average white light**

	Average R light (% of RGB sum)	Average G light (% of RGB sum)	Average B light (% of RGB sum)	Average RGB sum (%)	Average white light
Dif830 selected (18% B-light drop data)	73.6 (45.38%)	77.6 (47.80%)	11.1 (6.82%)	162.3 (100%)	854.53
Dif830 nonselected (remaining 82% data)	70.2 (36.83%)	93.7 (49.02%)	27.0 (14.16%)	190.9 (100%)	1005.34
Difference (percentage point change)	3.4 (8.55)	−16.1 (−1.22)	−15.9 (−7.33)	−28.6 (0)	−150.81

TABLE 2 Overall average values of reference lux; W_{Acti} light; W_{Acti} light C_{VAL}; RGB sum; and percentage R, G, and B light of the RGB sum, respectively, from the different calibrations. The tests were performed on a total of 48 Actiwatches

Treatment	Repeated tests included	Average reference lux	Average W_{Acti} light	Average W_{Acti} light C_{VAL}	Average RGB sum	RGB sum of W_{Acti} light (%)	R light of RGB sum (%)	G light of RGB sum (%)	B light of RGB sum (%)
Dif830	8	831.0	978.2	1.18	185.8	19.0	38.1	48.9	13.0
Dir830	4	985.2	1562.7	1.59	301.4	19.3	36.7	48.0	15.3
Halogen	3	227.2	468.1	2.06	112.8	24.1	59.0	31.3	9.7
IllA 250 lux	1	249.9	440.8	1.76	102.9	23.3	55.7	33.5	10.8
IllA 1000 lux	1	1000.0	1741.0	1.74	403.8	23.2	55.7	33.8	10.5
CloudySky	3	5885.0	9840.6	1.67	1863.1	18.9	26.2	50.8	22.9
IllD65 254 lux	1	253.9	639.0	2.52	125.8	19.7	26.7	48.2	25.2
IllD65 979 lux	1	978.6	2210.0	2.26	433.2	19.6	27.4	48.3	24.3

(Fig. 4C and Table 2). The highest IllD65 W_{Acti} light C_{VALs} were found when testing at the low IllD65 intensity and the C_{VALs} were found to be higher than the CloudySky W_{Acti} light C_{VALs}. CloudySky W_{Acti} light C_{VALs} were in closer agreement with the IllA C_{VALs} level (Figs. 4B and 4C and Table 2).

No relationship was found between the battery status of the Actiwatches and the measured light responses and thus the C_{VALs} found (data not shown).

The covering black cloth used to uncover and cover the Actiwatches at every calibration test was found to be necessary. One Actiwatch (S03056) time-keeper was approximately 10 minutes fast after 7 days; that is, after 7 days there were 40 fewer loggings (15-second intervals) stored for S03056 compared to the loggings of the rest of the Actiwatches. Thus, alignment of data was needed. This was found to be important especially for the daylight tests, where the light was not stable (CloudySky).

Daylight calibration at full sunshine was found to result in W_{Acti} light responses exceeding the maximum threshold of the Actiwatches (at 200,000 units W_{Acti} light) and the response being logged was "NaN." One sunlight calibration test where the reference sensor measured 98.5 klux resulted in 12 (out of 48) Actiwatches exceeding the maximum threshold and thus logging NaN (data not shown).

3.2. Comparing Different Calibration Methods

By comparing average C_{VALs} of W_{Acti} light and R, G, and B light, respectively, for Halogen versus IllA and CloudySky versus IllD65, we found the relationship and confidence intervals between the methods' average C_{VALs} (Fig. 7).

Similarity was found between measurements performed in the two light scenarios, Halogen and IllA, which are basically the same type of light source and show similar spectral compositions (Figs. 1C and 1D). Halogen and IllA showed similar slopes of regression lines and dependence between W_{Acti} light and RGB light responses (Figs. 6C and 6D). The Halogen W_{Acti} light C_{VAL} was found to correlate well with the IllA W_{Acti} light C_{VALs} (Figs. 7A and 7B).

The level of Halogen W_{Acti} light C_{VALs} was somewhat higher than for the IllA. However, relatively large standard errors per Actiwatch were found for Halogen, caused by the varying and relatively short distance to the light source and with imperfect light distribution in the measuring field.

The Actiwatch sensors exhibited a great deal of similarity in measurements made in the two light scenarios CloudySky and IllD65. This is evident when comparing the slopes of regression lines and the dependence between W_{Acti} light and R, G, and B light plotted for CloudySky and IllD65, respectively. CloudySky and IllD65 also showed similar spectral compositions (Figs. 1E and 1F). The CloudySky W_{Acti} light C_{VALs} correlated well with the IllD65 W_{Acti} light C_{VALs}. Due to the long distance to the light source (the sun) and the high degree of spatially distributed light from the overcast sky of approximately 6 klux at midday, the CloudySky calibration was found to result in small standard errors per Actiwatch.

4. DISCUSSION

4.1. The Need for Device-Specific Correction Factors

A correction factor is usually associated with the reciprocal value of the C_{VAL} used here and thus a multiplication

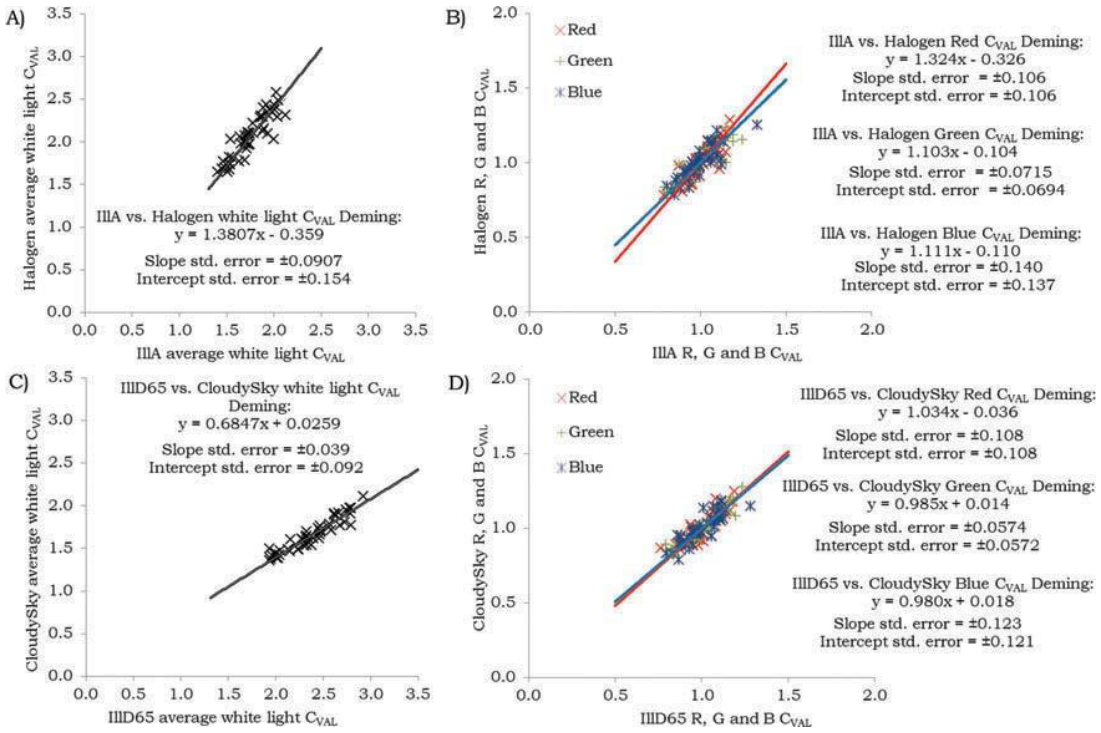

Fig. 7 **Different calibration methods used are compared by plotting the average C_{VAL} found for white, R, G, and B light. (A) Average white light C_{VAL} for IIIA and Halogen; (B) average R, G, and B light C_{VAL} for IIIA and Halogen; (C), average white light C_{VAL} for IIID65 and CloudySky; and (D) average R, G, and B light C_{VAL} for IIID65 and CloudySky. The slope and intercept of the associations and their confidence intervals are found using a functional model and Deming regression [Deal and others 2009].**

value. For simplification of the graphic interpretation, we used least squares regression inclination values (C_{VAL} = measured value/expected value).

It is important that equipment used in research is calibrated and that the light measurements are comparable between devices and across different experiments. The results from testing the Actiwatches clearly demonstrate the need for a field calibration method because large deviations were found between the Actiwatch devices. The need for correction is due to (1) the discrepancy between spectral sensitivity of the sensors and the photopic luminous efficiency function, $V(\lambda)$, and (2) because sensors' spatial responses may not always be cosine corrected. The latter influences the measurements because the light outside laboratory conditions is spatially spread in varying degrees. The variation of the measuring equipment used has to be dealt with. Relying on the calibration made by the manufacturer may not be enough, because equipment variations not dealt with will blur the effects being studied. Sensors used and reporting photopic illuminance are not necessarily cosine corrected and may have a great discrepancy to the $V(\lambda)$. Such sensors will in some cases lead to the wrong conclusions when used in continuously changing spectral and spatial light environments.

4.2. Overestimation of the Amount of Light in the Lighting Scenarios

We performed tests under different white light scenarios including fluorescent light, halogen light, and daylight. The variation in the spectral composition was expected to influence the C_{VALs} achieved. In a comparative study of three practical field devices, Figueiro and others [2013] reported a discrepancy between $V(\lambda)$ and the spectral response of W_{Acti} light of 83% (f_1' error). They also reported a discrepancy between a cosine distribution and the spatial sensitivity of the Actiwatches' sensors characterized by the f_2 statistics (f_2 error) of 31%, 39%, and 57%, for the R, G, and B sensors, respectively. The consequences are that the photometric measurements of common light sources are biased. When used in the field, Figueiro and others [2013] reported that Actiwatches systematically overestimate the amount of light to which a person is exposed when values are compared with those measured by a Daysimeter device.

In the present study, the Actiwatches' average W_{Acti} light C_{VALs} was found to differ between the lighting scenarios from 1.18 to 2.52. In the light environments tested and described here, Actiwatches (W_{Acti} light) thus

overestimated photopic illuminance by 18% to 152% depending on the light source and its spectral and spatial light distribution. This is comparable to earlier findings by Figueiro and others [2013]. Figueiro and others [2013] found Actiwatch measurement errors for diffused fluorescent illumination (3500K) and for diffused daylight of 37.1% and 99.9%, respectively.

4.3. Recommendations Concerning Procedures

When devices are tested simultaneously, they cannot be placed at the exact same position. Therefore, the distance to the light source did vary in the side-by-side tests. Light intensity is highly dependent on the distance to the light source, but we handled this by making several repetitions with random placement of the Actiwatches per light scenario and using an average measure. Using light sources for testing that are not stable requires that all measuring devices are tested at the same time. Daylight does change continuously. A relatively long distance to the light source is a major advantage because the relative difference in distances between the simultaneously calibrated devices and the light source becomes smaller. However, the intensity decreases with increased distance. Low intensity is, however, not a problem when using daylight at noon and the distance differences become negligible.

If the measurements are not made under the exact same light scenario, the measurements cannot be compared and used for finding variations between devices. Therefore, ensuring that the logged measurements are synchronized is very important. This was ensured by covering the devices with a black cloth when measurements were not performed and the loggings of light during tests could easily be aligned or if one of the devices had drifted in time as found for one Actiwatch.

That the Actiwatches were lined up and measured perpendicular to the direction to the light source was carefully practiced. The orientation perpendicular to the direction to the sun was of more importance for the calibration results under open sky than the repetitions with randomized placement, giving the directional response of the Actiwatches [Price and others 2012]. Moreover, the cloud cover is important. It was observed that placing the Actiwatches perpendicular to the direction to the sun mattered less during tests with completely overcast sky condition than during tests under only partly overcast sky conditions.

Because some of the Actiwatches (12 out of 48 at 98.5 klux) reached their W_{Acti} light maximum threshold during the sunlight calibration tests, it was not possible to calibrate Actiwatches in sunshine. The CIE standard overcast sky, which is clearly defined and used for calculating daylight factors [CIE 2014; Robbins 1986], is suggested to be the most appropriate to use. However, it is sufficient for the purpose of adjusting inter-equipment variability to test under a diffuse overcast sky.

4.4. Comparing the Calibration Methods, Halogen and IllA

For unknown reasons, the level of Halogen W_{Acti} light C_{VALs} was somewhat higher than for the IllA. This was unexpected considering the spatial characteristics of the light scenarios. The W_{Acti} light C_{VALs} should be highest for the more directed IllA light compared to that of the Halogen light scenario considering the spatial response of the sensors (Figueiro and others 2013; Price and others 2012]. It is unknown whether the divergence is related to the W_{Acti} light C_{VALs} estimations of the IllA or the Halogen calibration and therefore we cannot state that one method is superior to the other. However, correlations were found between the Halogen W_{Acti} light C_{VALs} and the IllA W_{Acti} light C_{VALs}.

4.5. Comparing the Calibration Methods, CloudySky and IllD65

The discrepancy between the level of IllD65 W_{Acti} light C_{VALs} and CloudySky W_{Acti} light C_{VALs} is most likely due to the fact that the light clearly differed between the calibration methods in how spatially distributed the light was. Contrary to the IllD65 calibration, the CloudySky calibration is considered more realistic in the C_{VAL} levels, because the light incidence on the Actiwatches will in practice often be multidirectional. However, there were large differences in illuminance intensities under which the IllD65 and the CloudySky calibration took place. The divergence may be related to both the W_{Acti} light C_{VALs} estimations of the CloudySky and the IllD65 light scenario, and we cannot state that one method is superior to the other. However, correlations were found between the CloudySky W_{Acti} light C_{VALs} and the IllD65 W_{Acti} light C_{VALs}.

4.6. Effects of Light Being Spatially Diffused Using a Frosted Polycarbonate Plate

A frosted polycarbonate plate placed in front of both the Actiwatch and the reference lux sensors in the Dif830 caused a 16% reduction in the average measured reference lux compared with Dir830 (reduction from 985 to 831 lux). In comparison, the Actiwatch sensors measured a reduction in the average W_{Acti} light to be as much as 37% (reduction from 1563 to 978 W_{Acti} light units). This reduction cannot be explained by the B-light drops or the changes in the percentage R, G, and B light of the average RGB sum that only changes slightly. That the relationship between R, G, and B light is more or less unchanged corresponds well with the fact that the measured spectral distribution is reduced equally across the range of visual wavelengths [SABIC Innovative Plastics 2009]. The diffusing effect of the frosted polycarbonate plate and the fact that less light from incident angles not being 90% is received by the Actiwatch sensors [Price and others 2012] compared with the cosine-corrected reference sensor primarily caused the discrepancy in reductions.

Polycarbonate is opaque to all wavelengths below 385 nm [SABIC Innovative Plastics 2009]. The small peak around 365 nm that appears in the Dir830 measured spectrum is not present in the spectrum of Dif830. Combining this with the earlier variability of the RGB sensors' spectral sensitivity of around 20% for the B light at 365 nm [Price and others 2012] may explain the B-light drop phenomenon. In particular, the B light sensor used in Actiwatches seems to be responsive to nonvisual wavelengths (ultraviolet light), and this can explain some of the reduced light measured in the Dif830 treatment by the RGB sensors. For unknown reasons, not all calibration test results for the Dif830 per Actiwatch coincided with each other. If the calibration is performed close to the smallest change in a measured value that the device can detect and the resolution in intensity steps is rough, then this could cause differences in the B light being measured. However, the B light intensity during the Dif830 test was around 10–30 $\mu W/cm^2$, whereas it was around 5–15 $\mu W/cm^2$ during the Halogen tests without any incidence of B-light drops in the Halogen tests. One explanation might be that there are different calibration scales used for the B light signal above and below a certain B light intensity and that the B light intensity split is around 20 $\mu W/cm^2$.

The change in the R, G, and B relationship (B-light drops) cannot explain the major reduction in both the average RGB sum and W_{Acti} light caused by the frosted polycarbonate.

The Actiwatch sensors' directional response is in disagreement with the reference sensors cosine response [Price and others 2012]. The frosted polycarbonate plate that diffuses the light was found to play a major role for the C_{VAL}, and this is the main reason for the reduction from the average Dir830 $C_{VAL} = 1.59$ to the average Dif830 $C_{VAL} = 1.18$, which equals a reduction of 26%.

4.7. Precautions for Straight-line Performance

We correlated the W_{Acti} light and the R, G, and B light, respectively, and we found differing slopes of the Deming regression lines depending on the light environments of the different tests. In the Deming regression analysis we included the offset of the sensors when measuring in darkness as an additional measuring point (Fig. 6). The results show that the measurements deviate to some extent from the regression lines found (Fig. 6). Therefore, the W_{Acti} light most likely depends on the contribution of the devices' R, G, and B wavelength band signals and the light environment. Alternatively, the assumption about the devices having a straight-line performance of the W_{Acti} light to the R, G, and B light may be false. Further tests using different intensities for calibration are needed in order to elucidate whether the devices have a straight-line performance. On the other hand, to use several C_{VALs} depending on the intensity will complicate a field test procedure.

4.8. Differences in the C_{VAL} Found

The two light intensities of IIlD65 did not result in the same C_{VALs}, which is most likely related to the reference lux measurement (Fig. 3B). The reference sensor had a relatively large detection area (approximately 7 cm^2) compared to that of the Actiwatch sensor. Adjustment of the light intensity was done by means of a filter and an adjustable collimated lens. During this process, the light distribution on the measuring field of both the Actiwatch sensor and the reference sensor may have changed, causing the difference in C_{VAL} levels of the two IIlD65 intensities.

The IIlA calibration resulted in W_{Acti} light C_{VALs} being higher than the values found for IIlD65. Thus, the spectral power distribution with the low percentage of B light and a high percentage of R light was found to result in lower C_{VALs} and vice versa. However, this is not true in all cases. The relative spectral response of Actiwatch spectrum has earlier been found to be almost insensitive to light emissions between 570 and 600 nm [Figueiro

and others 2013]. For this reason, Actiwatches underestimates photopic illuminance when used under, for example, high-pressure sodium light that still today is used as supplementary plant growth light by many commercial growers. Among other discharge light sources, fluorescent light also has emission lines in this wavelength range. The results shows that though the B light of the RGB sum was higher for Dif830 and Dir830 than for the Halogen and IllA tests, the W_{Acti} light C_{VALs} of Dif830 and Dir830 were lower.

4.9. Spectral Response and Suitable (Night) Applications

Correlations were generally vague for the R and B light, whereas the G light correlated better with the W_{Acti} light. The function of how W_{Acti} light is derived from the R, G, and B responses is unknown and not made public by the manufacturers. Nevertheless, our results suggest that the R and B responses play a minor role compared to the G response, which coincides somewhat with $V(\lambda)$ [CIE 2004] overlapping the spectrum of the G response more than the R and B spectral responses (for figures of the relative spectral sensitivity of Actiwatch R, G, and B sensors, please see Price and others [2012]). However, the G response coincides better with the eye sensitivity function of the scotopic vision regime, $V'(\lambda)$, and peaks around 500 nm, whereas the photopic eye sensitivity function peaks at 555 nm [CIE 2004; Price and others 2012]. The G spectral response of Actiwatches thus coincides better with night vision, although the W_{Acti} light is referred to as photopic.

In addition to light monitoring, personal exposure devices like Actiwatches are able to measure activity and thus sleep quality by registering a person's nightly activity. During nighttime, too much light can reset the circadian clock and therefore light monitoring during the night is often a prerequisite in studies centered on light-initiated circadian biological outcomes. Measuring light at low light intensities is therefore of interest to many circadian scientists studying sleep quality. However, combinations of activity and light measurements in one device can cause some practical difficulties; for example, because blankets (or sleeves) cover the light sensors. For daytime light levels, the W_{Acti} light offsets were found to be negligible with W_{Acti} light responses <1.1 when measuring in darkness. For daytime applications an offset correction will probably not be needed for the tested Actiwatches but it may introduce a measurement bias for low light levels. However, the G sensor spectral sensitivity found by Price and others [2012] is a good prerequisite for light monitoring during the night when light intensities are often low (scotopic vision).

4.10. Manufacturer's Changes of Products

As stated in Actiwatch's specification sheet [Philips Respironics 2013], "Philips Healthcare reserves the right to make changes in specifications and/or to discontinue any product at any time without notice or obligation." Therefore, the data presented here may not be valid, for example, for Actiwatch spectrum devices manufactured at a later date. However, if the measuring product is altered, the need for a simple calibration test when using both new and older types of measuring devices becomes even more relevant for researchers in order to ensure that the devices' measurements are in agreement.

4.11. Differences between the Actiwatches W_{Acti} Light C_{VALs}

Under the same light scenario, the Actiwatches tested differed in measurements of W_{Acti} light. The extreme maximum W_{Acti} light response measured by one Actiwatch was found to be more than 60% higher than the extreme minimum. The calibration tests performed were within illuminance intensities ranging from 250 and 5885 lux. All calibration tests showed the same trend of relatively high and low C_{VAL} values per Actiwatch, despite differences in the spectral composition of light for calibration and the span in illuminances.

As mentioned by Figueiro and others [2013], the manufacturer of Actiwatches states the typical accuracy to be 10% at 1500 lux [Koninklijke Philips 2014]. However, the results presented here clearly show that there is a significant difference of about 60% between Actiwatches tested in our repeated side-by-side tests, which does not correspond to the 10% stated by the manufacturer.

4.12. The R, G, and B Light in Relation to W_{Acti} Light

How the levels of the R and B light were originally set is unknown. Moreover, the units used are not definable but the relationship between RG and B offered by Actiwatches may be used to describe the light in terms of color. This may, if used, reveal new knowledge of the effect of colored and mixed light on well-being issues. However, RGB sensors other than the Actiwatch RGB sensor may most likely result in altered relations of RG and B under the

light scenarios tested. The relations found under selected light scenarios are specific for the Actiwatches.

4.13. Circadian Light Considerations

Light is considered the main human timekeeper and therefore light and health constitute important research fields throughout the world [Aries and others 2013; Czeisler 2013; Eisenstein 2013]. The spectrum of the complex non-image-forming photosensory system involved in the circadian, neuroendocrine, and neurobehavioral responses is not easily definable [Lucas and others 2014]. However, it appears to be most sensitive to blue light of 447–480 nm [Berson and others 2002; Brainard and others 2001; Cajochen and others 2005; Hanifin and Brainard 2007; Iskra-Golec and others 2012; Lucas and others 2014; Thapan and others 2001]. The B light response by Actiwatch spectrum devices peaks in this region [Price and others 2012]. Price and others [2012] suggested that blue light–weighted irradiance data from Actiwatches can be used as a spectral response for circadian studies. According to Price and others [2012], the ratio of 5 B:1 G light Actiwatch readout produces a bell-shaped sensitivity curve that peaks around 480 nm. Nevertheless, photopic illuminance is well defined and is measured in a one-dimensional unit, photopic lux. Hence, photopic illuminance is often used when linking light exposure and health-related issues. We used a photopic illuminance sensor as the reference in our calibration of Actiwatches. However, because of the complexity of the non-image-forming photosensory system and the diversity of broad-spectrum light sensors on the marked, it may still be best to measure the corneal spectral power distribution as suggested by Lucas and others [2014].

5. CONCLUSION

Our results provide a detailed depiction of the 48 Actiwatch devices' responses when calibrated side-by-side. The offset of the W_{Acti} light when measuring in darkness was found to range between 0 and 1.2 lux and thus negligible in most daytime applications but may be accounted for when used in low light intensity studies (Fig. 2).

The variability between the light measurements of the 48 Actiwatches tested was approximately 60% for W_{Acti} light during the calibration tests (Fig. 4). Furthermore, we confirmed earlier findings made by Figueiro and others [2013] that Actiwatches (the W_{Acti} light) often overestimate the actual photopic illuminance (Fig. 4). We found overestimations from 18% to 152% depending on light scenarios tested when compared against a calibrated cosine-corrected photopic illuminance sensor (Table 2).

Being specific for the Actiwatches, we found different relations between R, G, and B light versus W_{Acti} light under selected and described light scenarios. We confirmed earlier findings by Price and others [2012] showing that there is a clear correlation between the W_{Acti} light and G light, whereas the W_{Acti} light correlates to a lesser extent with R light and B light (Fig. 6). The correlation regression slopes found are dependent on light sources and conditions and are specific for the Actiwatch sensors tested.

Differences in the spatial light distribution will affect the correction values (C_{VAL}) when sensors are not cosine corrected and calibrated as described. For Actiwatches, we found that the diffusing effect of a frosted polycarbonate plate in front of the sensors under fluorescent light conditions caused a reduction in C_{VAL} of 26%. This is caused by the fact that only a minimum of light is received at incident angles $> 50°$ by the Actiwatch sensors [Figueiro and others 2013; Price and others 2012].

The CloudySky calibration C_{VALs} correlated with the IllD65 calibration C_{VALs} (Fig. 7C) and the relatively long distance to the light source (the sun) favor use of the CloudySky calibration while resulting in small standard errors (Fig. 4C). In some cases, using more than one light intensity for calibration is needed. Then again, to use several intensities and C_{VALs} per device will complicate a field calibration test procedure.

For comparable analysis and for applications with changing light conditions, we suggest calibrating Actiwatches' and similar light exposure devices' photopic illuminance output under overcast sky conditions against a calibrated cosine-corrected photometer perpendicular to the position of the sun, as described. We consider this field approach to be the best for calibrating light measuring devices of a lower quality.

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REFERENCES

Aries MBC, Aarts MPJ, van Hoof J. 2013. Daylight and health: a review of the evidence and consequences for the built environment. Lighting Res Technol. 0:1-22.

Berson DM, Dunn FA, Takao M. 2002. Phototransduction by retinal ganglion cells that set the circadian clock. Science, New Series. 295(5557):1070-1073.

Brainard GC, Hanifin JP, Greeson JM, Byrne B, Glickman G, Gerner E, Rollag MD. 2001. Action spectrum for melatonin regulation in humans: evidence for a novel circadian photoreceptor. J Neurosci. 21(16):6405-6412.

Cajochen C, Münch M, Kobialka S, Kräuchi K, Steiner R, Oelhafen P, Orgül S, Wirz-Justice A. 2005. High sensitivity of human melatonin, alertness, thermoregulation, and heart rate to short wavelength light. J Clin Endocr Metab. 90(3):1311-1316.

[CIE] Commission International de l'Éclairage. 2004. Colorimetry. 3rd ed. Vienna (Austria): CIE. Publication No. 15:2004. 72 p.

[CIE] Commission International de l'Éclairage. 2014. 17-169 CIE standard overcast sky. <http://eilv.cie.co.at/term/169> Accessed 2014 May 7.

Czeisler CA. 2013. Casting light on sleep deficiency. Nature. 497:S13.

Deal AM, Pate VW, Soumaya ER. 2009. A SAS ® macro for Deming regression. In: SESUG 2009; Proceedings of the SouthEast SAS Users Group, Birmingham, AL, USA, October 25-27, 2009. p. 1-7.

Eisenstein M. 2013. Stepping out of time. Nature. 497:S10-S12.

Figueiro MG, Hamner R, Bierman A, Rea MS. 2013. Comparisons of three practical field devices used to measure personal light exposures and activity levels. Lighting Res Technol. 45:421-434.

Hanifin JP, Brainard GC. 2007. Photoreception for circadian, neuroendocrine, and neurobehavioral regulation. J Physiol Anthropol. 26:87-94.

Hubalek S, Brink M, Schierz C. 2010. Office workers' daily exposure to light and its influence on sleep quality and mood. Lighting Res Technol. 42:33-50.

Iskra-Golec I, Wazna A, Smith L. 2012. Effects of blue-enriched light on the daily course of mood, sleepiness and light perception: a field experiment. Lighting Res Technol. 44:506-513.

Jost-Boissard S, Fontoynont M, Blanc-Gonnet J. 2009. Perceived lighting quality of LED sources for the presentation of fruit and vegetables. J Mod Optic. 56:1420-1432.

Koninklijke Philips NV. 2014. Philips respironics, Actiwatch spectrum specifications. <http://www.healthcare.philips.com/dk_da/homehealth/sleep/actiwatch/default.wpd#&&/wEXAQUOY3VycmVudFRhYlBhdGgFFkRldGFpbHM6U3BlY2lmaWNhdGlvbnOKh+5fzpW/Rh82+nJNs/BzMC6HpA==> Accessed 2014 Jul 4.

Lucas RJ, Peirson SN, Berson DM, Brown TM, Cooper HM, Czeisler CA, Figueiro MG, Gamlin PD, Lockley SW, O'Hagan JB, et al. 2014. Measuring and using light in the melanopsin age. Trends Neurosci. 37:1-9.

Mandel J, Lashof TW. 1974. Interpretation and generalization of Youden's two-sample diagram. J Qual Technol. 6:22-36.

Philips Respironics. 2013. Professional sleep and activity monitoring solutions. <http://www.healthcare.philips.com/pwc_hc/main/homehealth/sleep/actiwatch/pdf/ActiwatchSpecSheetFinal.pdf> Accessed 2014 Jul 4.

Price LLA, Khazova M, O'Hagan JB. 2012. Performance assessment of commercial circadian personal exposure devices. Lighting Res Technol. 44:17-26.

Rautkyla E, Puolakka M, Halonen L. 2011. Alerting effects of daytime light exposure—a proposed link between light exposure and brain mechanisms. Lighting Res Technol. 44:238-252.

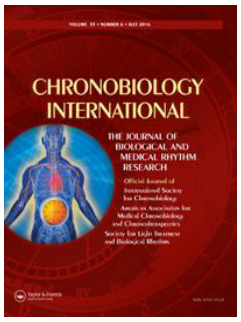
Rea M. 2006. A second kind of light. Optics and Photonics News. 17:34-39.

Robbins CL. 1986. The daylight and sunlight resource. In: Daylighting: design and analysis. 1st ed. New York (NY): Van Nostrand Reinhold Company. p. 29-58.

SABIC Innovative Plastics. 2009. Lexan* sheet, solid un-coated and coated sheet, Technical Manual. <https://sfs.sabic.eu/wp-content/uploads/resource_pdf/1345453948-48623687-Technical-Manual-Coated-Uncoated-Sheet.pdf> Accessed 2014 Jan 28.

Thapan K, Arendt J, Skene DJ. 2001. An action spectrum for melatonin suppression: evidence for a novel non-rod, non-cone photoreceptor system in humans. J Physiol. 535:261-267.

Veitch JA, Galasiu AD. 2012. The physiological and psychological effects of windows, daylight, and view at home: review and research agenda. Ottawa, ON (Canada): National Research Council of Canada, Institute for Research in Construction. IRC-RR-325. 59 p. Available from http://archive.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc54002.pdf.



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How do different definitions of night shift affect the exposure assessment of night work?

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How do different definitions of night shift affect the exposure assessment of night work?

Anne Helene Garde[a,b], Johnni Hansen[c], Henrik A. Kolstad[d], Ann Dyreborg Larsen[a], and Åse Marie Hansen[a,b]

[a]National Research Centre for the Working Environment, Copenhagen, Denmark; [b]Department of Public Health, University of Copenhagen, Copenhagen, Denmark; [c]Research Center, The Danish Cancer Society, Copenhagen, Denmark; [d]Department of Occupational Medicine, Danish Ramazini Centre, Aarhus University Hospital, Aarhus, Denmark

ABSTRACT

The aim is to show how different definitions affect the proportion of shifts classified as night shifts. The Danish Working Hour Database was used to calculate number of night shifts according to eight definitions. More than 98% of the total night shifts were night shifts by use of both the reference definition (at least 3 h of work between 24:00 and 05:00) and definitions using a period during the night. The overlap with definitions based on starting and ending time was less pronounced (64–71 %). The proportion of classified night shifts differs little when night shifts are based on definitions including a period during the night. Studies based on other definitions may be less comparable.

KEYWORDS

Shift work; pay-roll data; night work

Background

Associations between night shift work and cancer, in particular breast cancer, have attracted attention during the past decades, and night shift work that involves circadian disruption has been suggested as carcinogenic to humans (Stevens et al., 2011). However, despite increasing epidemiological research on non-day work and breast cancer based on both case–control and cohort studies, where the majority of studies support such an association, risk estimates vary between studies.

One reason for inconsistencies in results may be related to the fact that non-day work is defined and characterized differently in the studies. Some studies define night shift work as working the entire period 24:00–05:00 (Pesch et al., 2010) or 24:00–06:00 (Lie et al., 2011; Papantoniou et al., 2015). Others specify a shorter period, e.g. at least 3 h of work between 24:00 and 05:00 as suggested as a standard by Stevens et al. (2011), ≥3 h between 23:00 and 06:00 (Harma et al., 2015) or any hour between 01:00 and 04:00 (Schwartzbaum et al., 2007). Start and ending times have also been used: beginning work after 19:00 and ending before 09:00, the following morning (graveyard shift) (Davis et al., 2001; Hansen & Stevens, 2012; O'Leary et al., 2006), starting between 19:00 and 04:00 and ending after 01:00 (Garde et al., 2012) and starting work between 22:00 and 06:00 (Pronk et al., 2010). Some registry-based studies from the pioneering period of this research area had even broader and unspecific definitions of non-day work based on, e.g. job title (Hansen, 2001; Lie et al., 2006; Tynes et al., 1996). Such differences in definitions lead to differences in exposure classification and exposure contrast across studies and make it difficult to compare and interpret results, and conduct meta-analyses.

However, the consequences of these differences in definitions for the distribution of night work are not fully elucidated. Differences in exposure assessment will consequently influence the proportion of exposed and non-exposed study subjects and thereby affect risk estimates in epidemiological studies if a true association exists. The aim of the present study was to show how different definitions of night work affect the proportion of shifts classified as night shifts in the Danish healthcare sector.

Methods

We used the recently established Danish Working Hour Database (DWHD) with information on

CONTACT Anne Helene Garde National Research Centre for the Working Environment, Lerso Parkallé 105, DK-2100 Copenhagen, Denmark.

individual working time from 2007 to 2013 to calculate and compare the number of night shifts based on eight different definitions. DWHD contains administrative payroll data on working hours including information on daily starting and ending times for each shift for all employees in the five Danish administrative regions. The main reason for the exact time registrations is calculation of salary which is influenced by the time of the day and week. The primary task of the regions is to run the public hospitals, and DWHD includes information on all employees in Danish public hospitals from 2007 to 2013.

In total, the DWHD includes information on 234 297 individuals. Of all participants, 79% were women, 50% were employed as nurses or caretakers, 11% were physicians and 40% were administrative or technical staff. The age distribution was ≤ 30 years (12%), 31–40 years (24%), 41–50 years (23%) and >50 years (39%). The database was approved for research by The Danish Data Protection Agency (ref no.: 2011-41-7046 and 2015-57-0074).

Data were obtained from two Danish commercial providers of payroll systems: Silkeborg Data (four regions; 2007–2013) and KMD (one region; 2008–2013). The raw data included one record for each shift or type of salary payment, e.g. sick leave. Observations not related to working hours, e.g. payments for clothing, diets, and pension, were deleted.

The database includes information on regular working hours, overtime and on-call hours, which are all classified as work in the present study. Consecutive observations of working hours were combined into one registration defined by the starting time and ending time. Registrations less than 60 min apart were collapsed into one shift, i.e. gaps of less than 60 min were considered work time. Gaps of more than 60 min were considered time off, and working hours prior and subsequent to the gap were recorded as two independent shifts. Thus, there may be more than one shift per day.

We compared the influence of exposure assessment on non-day working time of eight different definitions of night shift work primarily from literature on shift work and breast cancer (Davis et al., 2001; Garde et al., 2012; Hansen & Stevens, 2012; Harma et al., 2015; Lie et al., 2011; O'Leary et al., 2006; Papantoniou et al., 2015; Pesch et al., 2010; Pronk et al., 2010; Schwartzbaum et al., 2007; Stevens et al., 2011). The selection covers studies using questionnaire, interview and payroll data as well as Asian, European and American populations. Five definitions classified night shift based on a time period worked during night: (1) at least 3 h of work between 24:00 and 05:00 (reference) (Stevens et al., 2011), (2) the entire period between 24:00 and 5:00 (Pesch et al., 2010), (3) any hour between 24:00 and 06:00 (Lie et al., 2011; Papantoniou et al., 2015), (4) ≥3 h between 23:00 and 06:00 (Harma et al., 2015), (5) any hour between 01:00 and 04:00 (Schwartzbaum et al., 2007). Three definitions classified night shift on the basis of starting and/or ending time of shift: (6) beginning work after 19:00 and leaving work before 09:00 (graveyard shift) (Davis et al., 2001; Hansen & Stevens, 2012; O'Leary et al., 2006), (7) starting between 19:00 and 04:00 and ending after 01:00 (Garde et al., 2012) and (8) starting work after 22:00 and ending before 06:00 (Pronk et al., 2010).

Results

Table 1 compares definitions of night shifts with the reference [A = at least 3 h of work between 24:00 and 05:00 (definition 1)]. The column "In A or B" indicates the total number of shifts classified as night shifts based on either one of the two definitions. The columns "In A" and "In B" indicate the percentage of total night shifts which are classified according to A and B, respectively, and the last column shows the percentage of total night shifts classified according to both A and B. Thus, it is possible to calculate the number of shifts classified according to either of the two definitions and the overlap between A and B.

As presented in Table 1, more than 98% of the total night shifts, i.e. shifts classified as night based on either of the two definitions, were classified as night shifts by both the reference and the definitions including a specified period during the night (definitions 2–5). The corresponding overlap between the reference and the graveyard shift definition (starting after 19:00 and ending before 09:00) was 67%. When defining night shift work as starting between 19:00 and 4:00 and ending

Table 1. Comparison of night shifts according to different definitions.

A (ref)	B	In A or B[a]	In A[b]	In B[c]	In A and B[d]
		n	%	%	%
Definitions specifying a period of working time during night					
At least 3 h between 24:00 and 05:00	(2) Period between 24:00 and 5:00	10.418.331	100	98	98
At least 3 h between 24:00 and 05:00	(3) Period between 24:00 and 06:00	10.418.331	100	98	98
At least 3 h between 24:00 and 05:00	(4) ≥3 h between 23:00 and 06:00	10.541.694	99	100	99
At least 3 h between 24:00 and 05:00	(5) Any hour between 01:00 and 04:00	10.607.410	98	100	98
Definitions based on starting and/or ending time of shift					
At least 3 h between 24:00 and 05:00	(6) Beginning after 19:00 and leaving before 09:00	11.148.693	93	73	67
At least 3 h between 24:00 and 05:00	(7) Starting between 19:00 to 4:00 and ending after 01:00	10.603.059	98	73	71
At least 3 h between 24:00 and 05:00	(8) Starting after 22:00 (and ending before 06:00)	11.160.879	93	70	64

[a]The total number of shifts classified as night shifts based on two definitions.
[b]Percentage of total night shifts classified according to A.
[c]Percentage of total night shifts classified according to B.
[d]Percentage of total night shifts classified according to A and B.

after 01:00, there was a 71% overlap with the reference. When night shifts were defined as work starting after 22:00 and (by us defined as) ending before 06:00, only 64% of the shifts overlap with the reference definition

Discussion

Different definitions of night shifts affect the proportion of night shifts. The present study shows that the discrepancy is minor when night shifts are defined by specified short periods of night time (definitions 2–5). However, studies defining night by starting and ending time (definitions 7–9) may be less optimal with respect to studying if specific timing has biological impact, as suggested for breast cancer (Stevens et al., 2011). There are other factors which may explain the differences observed in studies of night work and breast cancer, e.g. the organization of night shifts such as number of consecutive shifts, proportion of part-time work, and the selection of reference group. A corresponding analysis of the consequences of such differences would be beneficial.

The present study covers a relatively limited group of public servants in Denmark, mainly nurses and physicians in public hospitals. Due to collective agreements, working time for these employees is to some extent harmonized all over Denmark. It is, however, speculated that the results may be generalized to some other public sectors and possibly industrial jobs requiring 24 h services. Yet, it is questionable whether the working time patters observed in this study can be generalized to other sectors, e.g. transport, or other countries.

This study benefits from the large amount of data and objective information on working hours as all data were drawn from payroll registers and therefore were independent of subjective perceptions of "being a night-worker". The registration of working hours is expected to have high validity since it forms the basis of pay, which depends on the time of day. In the future, data on working hours from the DWHD will be used to investigate associations between specific working hour characteristics such as length of shifts, time between shifts, and number of consecutive night shifts and health outcomes by linkage to national health registers at an individual level. This is possible in Denmark due to the existence of a unique individual ID number and a data protection law which is in favour of register research (Schmidt et al., 2014).

Declaration of interest

The authors report no conflicts of interest.

References

Davis S, Mirick DK, Stevens RG. (2001). Night shift work, light at night, and risk of breast cancer. J Nat Cancer Inst. 93:1557–62.

Garde AH, Albertsen K, Nabe-Nielsen K, Carneiro IG, Skotte J, Hansen SM, et al. (2012). Implementation of self-rostering (the PRIO-project): Effects on working hours, recovery, and health. Scand J Work Environ Health. 38:314–26.

Hansen J. (2001). Increased breast cancer risk among women who work predominantly at night. Epidemiology. 12:74–7.

Hansen J, Stevens RG. (2012). Case-control study of shift-work and breast cancer risk in Danish nurses: Impact of shift systems. Eur J Cancer. 48:1722–29.

Harma M, Ropponen A, Hakola T, Koskinen A, Vanttola P, Puttonen S, et al. (2015). Developing register-based measures for assessment of working time patterns for epidemiologic studies. Scand J Work Environ Health. 41:268–279.

Lie JA, Kjuus H, Zienolddiny S, Haugen A, Stevens RG, Kjaerheim K. (2011). Night Work and Breast Cancer Risk Among Norwegian Nurses: Assessment by Different Exposure Metrics. Am J Epidemiol. 173:1272–79.

Lie JA, Roessink J, Kjaerheim K. (2006). Breast cancer and night work among Norwegian nurses. Cancer Causes Control. 17:39–44.

O'Leary ES, Schoenfeld ER, Stevens RG, Kabat GC, Henderson K, Grimson R, et al. (2006). Shift work, light at night, and breast cancer on Long Island, New York. Am J Epidemiol. 164:358–66.

Papantoniou K, Castano-Vinyals G, Espinosa A, Aragones N, Perez-Gomez B, Ardanaz E, et al. (2015). Breast cancer risk and night shift work in a case-control study in a Spanish population. Eur J Epidemiol.

Pesch B, Harth V, Rabstein S, Baisch C, Schiffermann M, Pallapies D, et al. (2010). Night work and breast cancer - results from the German GENICA study. Scand J Work Environ Health. 36:134–41.

Pronk A, Ji BT, Shu XO, Xue S, Yang G, Li HL, et al. (2010). Night-shift work and breast cancer risk in a cohort of Chinese women. Am J Epidemiol. 171:953–59.

Schmidt M, Pedersen L, Sorensen HT. (2014). The Danish Civil Registration System as a tool in epidemiology. Eur J Epidemiol. 29:541–49.

Schwartzbaum J, Ahlbom A, Feychting M. (2007). Cohort study of cancer risk among male and female shift workers. Scand J Work Environ Health. 33:336–43.

Stevens RG, Hansen J, Costa G, Haus E, Kauppinen T, Aronson KJ, et al. (2011). Considerations of circadian impact for defining 'shift work' in cancer studies: IARC Working Group Report. Occup Environ Med. 68:154–62.

Tynes T, Hannevik M, Andersen A, Vistnes AI, Haldorsen T. (1996). Incidence of breast cancer in Norwegian female radio and telegraph operators. Cancer Causes Control. 7:197–204.

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Short-term effects of night shift work on breast cancer risk: a cohort study of payroll data

by Vistisen HT, Garde AH, Frydenberg M, Christiansen P, Hansen ÅM, Hansen J, Bonde JPE, Kolstad HA

The epidemiological evidence of an association between night shifts and breast cancer is limited. Studies have relied on self-reported information on working time, which may have inflated findings by recall bias. This study included individual, objective, and detailed information on working time from pay roll registers. There is no increased risk of breast cancer following recent night shift work.

Affiliation: Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark. henkol@rm.dk

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Key terms: breast cancer; cancer; circadian disruption; cohort study; effect; epidemiology; night shift work; payroll data; shift work; shift worker; working time

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Additional material

Please note that there is additional material available belonging to this article on the *Scandinavian Journal of Work, Environment & Health* -website.

Original article

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Short-term effects of night shift work on breast cancer risk: a cohort study of payroll data

by Helene Tilma Vistisen, PhD,[1] Anne Helene Garde, PhD,[2] Morten Frydenberg, PhD,[3] Peer Christiansen, MD,[4, 5] Åse Marie Hansen, PhD,[2, 6] Johnni Hansen, PhD,[7] Jens Peter E Bonde, MD,[8] Henrik A Kolstad, MD [1]

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Objectives The objective was to examine if night shift work is a short-term risk factor for breast cancer, including combined estrogen receptor (ER) and human epidermal growth factor 2 (HER2) breast cancer subtypes.

Methods The cohort comprised 155 540 public sector female workers in Denmark who were followed from 2007–2012. Day-to-day work-hour information was available from payroll registers and 1245 incident cases of breast cancer were identified in national cancer registries together with receptor subtype information.

Results A rate ratio (RR) of 0.90 [95% confidence interval (95% CI) 0.80–1.01] was observed for workers ever working night shifts during the follow-up period compared with workers only working day shifts after adjustment for age, age at first child, parity, family history of breast or ovarian cancer, sex hormones, medications related to alcoholism, family educational level, mammography screening, and other potential confounders. Comparable results were seen for the inception population of employees with first recorded employment after 2007. Modestly increased RR were suggested for breast cancer subtypes characterized by a positive HER2 status irrespective of ER status.

Conclusions These findings do not support an overall short-term effect of night shift work on breast cancer risk. Future studies should explore further the impact of HER2 status.

Key terms circadian disruption; epidemiology; shift worker; working time.

In 2007, a working group convened by the International Agency for Research on Cancer (IARC) classified night shift work that involves circadian disruption as probably carcinogenic to humans based on sufficient evidence in animals, and limited evidence in humans (1). Since then several epidemiologic studies and systematic reviews have been published, but despite these efforts the epidemiological evidence is still limited (2–5).

Reduction of nocturnal pineal melatonin production is suggested as a pivotal element of the mechanisms linking night shift work and breast cancer (6–13). From animal studies it is known that melatonin reduces the growth of chemically induced mammary tumors (10, 14). It has also been shown that melatonin at physiological levels suppresses the proliferation of human breast cancer xenografts (15–17). Furthermore, melatonin may reduce the invasiveness of human breast cancer, and the suppression of melatonin during the biological night may act as a promoter of oncogenesis (10, 16). This experimental evidence suggests that suppression of melatonin from night shift work may exert its response downstream the complex casual pathways that lead to breast cancer. Hence, recent night shift work may be associated with short-term risk of breast cancer in humans.

1 Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark.
2 National Research Centre for the Working Environment, Copenhagen, Denmark.
3 Section for Biostatistics, Department of Public Health, Aarhus University, Aarhus, Denmark.
4 Department of Breast Surgery, Aarhus University Hospital, Aarhus, Denmark.
5 Danish Breast Cancer Corporative Group (DBCG); City, Denmark.
6 Department of Public Health, University of Copenhagen, Copenhagen, Denmark.
7 Danish Cancer Society Research Center, Copenhagen, Denmark.
8 Department of Occupational and Environmental Medicine, Bispebjerg University Hospital, Copenhagen, Denmark.

Correspondence to: Henrik A Kolstad Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark. [E-mail:henkol@rm.dk].

Of the several epidemiologic studies conducted, only three studies have examined possible short-term risk of recent night shift work (18–20). Davis et al observed an increased risk of breast cancer among women who ever worked the graveyard shift during the last ten years (19). However, Pesch et al (18) did not corroborate this finding. The well-established effects of prolonged exposure of breast tissue to estrogen vary according to breast cancer receptor subtypes and are most consistent for the hormone dependent tumors (21–23). This suggests distinct etiologic pathways for breast cancer subtypes and new risk factors may be overseen if this is not accounted for (24). Night shift work has been associated with estrogen receptor positive (ER+) (25–29), ER- (26, 30), progesterone receptor positive (PR+) (26–29), human epidermal growth factor 2 positive (HER2+) (29, 31) and HER2- breast cancer subtypes (29). The strongest association was reported for HER2+ in combination with ER+ or PR+ receptor status (29).

Previous studies of the association between night shift work and breast cancer have relied on crude and self-reported information on working time, and findings may have been influenced by non-differential as well as differential misclassification of exposure that perhaps only can be circumvented by continuously and objectively recorded information of working hours (2).

The present study combines day-to-day information on exact working time obtained from a large and recently established payroll register with cancer incidence and tumor receptor subtype information. The objective was to examine if night shift work is a short-term risk factor for overall breast cancer and combined ER and HER2 receptor breast cancer subtypes.

Methods

Data sources

This study linked information from seven Danish registries on the individual level by use of the civil registration number given to all residents in Denmark since 1968: (i) *The Danish Working Hour Database* is a newly established database encompassing all employees of each of the five administrative regions, which operate in healthcare and other public sectors. The database covers individual payroll information on day, hour, and minute of the beginning and end of every work shift and information on occupation. Data have been available since 1 January 2007 for four of the regions and from 2008 for all regions; (ii) *The Civil Registration System* encompasses all residents in Denmark with information on sex, vital status, date of birth and links to first degree relatives since 1968 (32); (iii) *The clinical database of the Danish Breast Cancer Corporative Group* includes pathological and clinical information on all new diagnosed breast cancers diagnosed since 1977 as well as information on ER and HER2 status (33); (iv) *The Danish Cancer Registry keeps* records on all cancers diagnosed classified according to ICD-7 and ICD-10 codes (the International Classification of Diseases), and date of diagnosis since 1943 (34); (v) *The National Register of Medicinal Product Statistics* encompasses all purchases of prescription drugs at private pharmacies with information on the medication by ATC codes (the Anatomical Therapeutic Chemical Classification System), date of purchase, and purchaser (35). Data have been available since 1995; (vi) *The Family Income Register from Statistics Denmark* encompasses all individuals born or living in Denmark with information on the highest educational level in a family living at the same address (36). We included information as of 1 January 2007; (vii) *The Clinical Database of Mammography Screening* records women aged 50–69 years and invited to participate in the national mammography screening programme (37). The database includes information on dates of invitation and examination since the start of the program by the end of 2007.

Data were retrieved up to and including 31 December 2012 for all registers, though Danish Cancer Registry data were only available up to 31 December 2011.

The Danish Data Protection Agency approved the study (j.no. 2011-41-6850). In Denmark, register studies do not need the approval of the Danish Health Research Ethics Committee System.

Study population

The study population was women aged ≥18 years with ≥1 registration of work in the Danish Working Hour Database between 1 January 2007 and 31 December 2011 (N=156 927). We excluded 1357 women diagnosed with breast cancer prior to follow-up, one woman with missing date of breast cancer diagnosis, and 29 women who had <3 consecutive hours of work. The final study population included 155 540 women free of breast cancer at start of follow-up.

We had no information on the study participants' working hours prior to 2007. Therefore, to reduce possible bias and confounding from night shift work prior to 2007 we established a sub-population of subjects first employed by 1 January 2008 or later (the inception population). This included subjects with no recorded employment in any of the regions during 2007 (washout period) and was possible for employees in four of the five regions. In total 55 381 (35.6%) fulfilled the criterion.

Breast cancer

Breast cancer cases and date of diagnosis together with information on ER and HER2 status were identified in the clinical database of the Danish Breast Cancer Corporative Group for all available years and supplemented with breast cancer cases from the Danish Cancer Registry [ICD-10 code C50 (1978–2012) or ICD-7 code 170 (<1978)]. Cases were classified into four subtypes on the basis of their ER and HER2 status: (i) ER-/HER2-, (ii) ER+/HER2-, (iii) ER-/HER2+, and (iv) ER+/HER2+ tumors. Progesterone receptor status is strongly associated with ER status and has not been routinely analyzed in Denmark since 2007. Information on PR status was only available for a small subset of cases and was not included for the analyses.

ER status was defined using a cut-off at 10% positive estrogen cells. HER2 status was established using immunohistological markers from 0–3+, where 2+ is regarded as "equivocal", and 3+ as positive. In cases which were equivocal (2+), the immunohistological test was supplied with fluorescence or chromogenic in situ hybridization (FISH and CISH test, respectively), and the tumor was classified as positive (HER2+) if oncogenic amplification was found (38).

Definition of shifts

A night shift was defined according to a 2009 IARC working group as ≥3 hours of work between midnight and 05:00 hours (39). We defined a day shift as ≥3 hours of work between 06:00–20:00 hours and all other shifts of ≥3 hours as a non-day, non-night shift. In the analyses, we considered six different exposure time windows: Since entry, and the past 1, 1–2, 1–3, 1–4, and 1–5 years.

At a given day in the follow-up and with a chosen exposure time windows, a woman was classified as working: (i) only day shifts if she only had day shifts throughout the time window; (ii) ever non-day/non-night shift, if she had ≥1 non-day shift but no night shift in the time window; and (iii) ever night shift if she had ≥1 night shift in the time window.

The cumulated number of night shifts since entry was divided into four categories defined by the person-year quartiles. The mean numbers of night shifts during the past 1, 1–2, 1–3, 1–4, and 1–5 years time windows were calculated and categorized into four groups: 0.1–0.9, 1.0–3.9, 4.0–9.9, and ≥10.0 night shifts per month.

Covariates

From the registries, information was retrieved on age, age at birth of first child, number of children, a family history of either breast cancer before the age of 50 or ovarian cancer at any age among female first degree relatives (mothers and sisters), use of oral contraception, hormone replacement therapy, other hormone medications in the G03 ATC group, use of medications related to alcohol over-consumption and addiction (ATC groups N03AA, N05AB and N07BB), highest educational level in the family, and attending mammography screening. These potential confounders were based on register availability, a review of the literature, and decided upon a priori (40, 41). Data were virtually complete within the time frame of available data for all variables except for female first degree relatives (5% missing). Missing values were evenly distributed across work hour categories.

Statistical analysis

Each woman was followed on a daily basis from start of follow-up, which was the first registration of work (earliest on 1 January 2007) until the date of first primary breast cancer diagnosis, death, disappearance, emigration, or end of follow-up at 31 December 2012. In the analyses of mean number of night shifts during the past exposure time windows, follow-up started subsequent to the end of a time window and the earliest one year after the first registration of work for the one-year time window.

Data were analyzed as incidence rate, ie, as the number of incident breast cancer cases per time units at risk. We computed rate ratios (RR) of overall breast cancer with Poisson regression and breast cancer subtypes by stacked Poisson regression by the different night shift metrics. The only day shift category was the reference. A separate RR estimate was provided for the ever non-day, non-night category (presented in the supplementary material www.sjweh.fi/index.php?page=data-repository). The stacked Poisson regression analysis was based on a table combining person years at risk and number of events for ER-/HER2-, ER+/HER2-, ER-/HER2+, ER+/HER2+, and unclassified tumors (no receptor status available). This allowed us to test whether the association between night shift work and the incidence of breast cancer differed between subtypes. Both crude and adjusted estimates were reported.

Age, age at birth of first child, number of children, a family history of breast cancer or ovarian cancer, and hormone replacement therapy may have distinct effects on breast cancer subtypes (42–44). Therefore, we divided the potential confounders into two sets of covariates: (A) age (<40, 40–44, 45–49, and every second year from age 50), age at birth of the first child (<20, 20–29, ≥30, no children), number of births (0, 1, 2, 3, ≥4), family history of breast cancer or ovarian cancer (0, ≥1, no information), hormone replacement therapy (no, yes); and (B) calendar year (each year 2007–2012), oral contraceptives (no, yes), other sex hormones (no, yes), medication related to alcoholism, (no, yes), mammography screening attendance (invited but not screened, invited and screened, not

invited), and highest family educational level at the first registration of work (unspecified, primary and secondary school, advanced level education, vocational education, undergraduate and bachelor degree, higher education, and no information on education). Analyses of overall breast cancer included all sets of A and B covariates. In the adjusted stacked Poisson regression models, the effects of the covariates in set A were allowed to differ between breast cancer subtypes while the covariates in set B were assumed to have the same effect on the rate independently of the subtype.

All variables were time dependent, ie, varied for each date from start until the end of follow-up. Estimates were reported with a 95% confidence interval. Two different trend analyses were conducted across the grouped cumulated and average number of night shifts; the one was restricted to ever night shifts, the other included only day shift as a null exposed category. All data management and analyses were done with Stata 14.1 (Stata Corp, College Station, TX, USA).

Results

The 155 540 women contributed a total of 771 062 person years and 1245 breast cancer cases during follow-up. ER status was available for 1177 (95%) cases, HER2 status for 1123 (90%) cases, and both ER and HER2 status for 1118 (90%) cases. In total 136 ER-/HER2-, 797 ER+/HER2-, 77 ER-/HER2+, 108 ER+/HER2+, and 127 not classifiable (because of missing receptor status) breast cancer cases were included. The inception population included 55 381 women and contributed a total of 199 617 person years and 230 breast cancer cases, 14 ER-/HER2-, 151 ER+/HER2-, 28 ER-/HER2+, 18 ER+/HER2+, and 19 not classifiable receptor subtypes.

Table 1 presents the distribution of age and age-standardized participant characteristics of person years by exposure status (only day shifts and ever night shifts) since study entry for the total population. Supplementary table A (www.sjweh.fi/index.php?page=data-repository) provides this information also for the ever non-day, non-night shift category and for quartiles of night shifts. Women who worked night shifts had a higher family educational level and were overall younger than women working only day shifts. Except from this, age-standardized person years were evenly distributed by participant characteristics and work hours. Healthcare professionals constituted 40%, personal care workers 23%, technicians 15%, elementary occupations 10%, and clerical support workers 5% of the employees.

In the inception population, more non-night shift workers did not have children, and this group was also less educated than the night shift workers (data not shown). The mean age of the inception population was 35.5 years compared to 39.4 years in the total population.

Table 2 presents rate ratios for all breast cancer and the four breast cancer subtypes defined by the cross classification of ER and HER2 status by night shifts since entry in the total study population. Overall decreased RR for all breast cancer was observed

Table 1. Age and age-standardized participant characteristics of person years (%) among female employees of the Danish public sector working only day or ever night shifts 2007–2012. [a]

Participant characteristics	Only day shifts (412 920 person years)	Ever night shifts (318 210 person years)
Age (years)		
<40	40	49
40–49	25	25
50–59	23	20
≥60	12	6
Calendar year of follow-up		
2007	13	9
2008	16	14
2009	17	17
2010	18	19
2011	18	20
2012	18	21
Age at first child's birth		
<20 years	5	4
20–29 years	53	57
≥30 years	16	16
No children	26	23
Number of children		
0	26	23
1	17	17
2	40	39
3	14	18
≥4	3	4
Family history of breast or ovarian cancer		
No	90	91
Yes	2	3
No information	8	7
Oral contraception		
No	39	38
Yes	61	62
Hormone replacement therapy		
No	75	75
Yes	25	25
Other sex hormones		
No	88	87
Yes	12	13
Medications for alcoholism		
No	98	99
Yes	2	1
Mammography screening		
No	4	4
Yes	16	18
Not invited	80	78
Highest family education		
Unspecified	1	1
Primary and secondary school	8	2
Advanced level education	36	25
Vocational education	6	2
Undergraduate and bachelor degree	31	54
Higher education	18	16
Missing	0	0

[a] A total of 39 932 person years of employees ever working non-day, non-night shifts were not included.

(adjusted RR 0.90, 95% CI 0.80–1.01). The ER+/HER2- subtype showed a RR of 0.80 (95% CI 0.68–0.95) and a decreasing trend by increasing number of night shifts when day worker were included as a null-exposed category in the trend test (P=0.05), but not when tested within the night shift workers only. A decreased RR was also seen for ER-/HER2- but not of statistical significance.

Non-significantly increased RR were observed for the ER-/HER2+ and ER+/HER2+ subtypes (RR 1.49, 95% CI 0.93–2.39 and RR 1.26, 95% CI 0.84–1.89, respectively). For the former subtype, an increasing trend by increasing number of night shifts was seen (P<0.05), but not when tested within the night shift workers only.

We observed a decreased association between ever working night shift during the past one year time window and all breast cancer (RR 0.80, 95% CI 0.69–0.93) and a decreasing trend (P=0.01) by the mean number of night shifts when day workers were included in the test (table 3). Such trends were also seen for the other time windows, except for the past 1–5 years window, but not when tested among the night shift workers only.

Table 4 presents associations between all breast cancer and night shifts since entry and during the past 1 to 1–4 years time windows in the inception population. In the crude analyses, we observed a decreased RR for all breast cancer following night shift work the past 1 year (RR 0.69, 95% CI 0.48–0.98). This association was attenuated in the adjusted analyses and none of the adjusted RR estimates differed statistically from unity.

We observed age, age at birth of first child, family history of breast cancer or ovarian cancer, mammography screening attendance, family educational level to be associated with increased breast cancer risk, all as expected. Supplementary tables A–D (www.sjweh.fi/index.php?page=data-repository) correspond with tables 1–4 but include comprehensive and more detailed data. No increased risk of breast cancer was seen for the ever non-day, non-night shifts category in neither the total nor the inception population.

Table 2. Rate ratios (RR) and 95% confidence intervals (95% CI) of all breast cancer and combined estrogen receptor (ER) and human epidermal growth factor 2 (HER2) breast cancer subtypes by night shifts since start of follow-up. Results from female employees of the Danish public sector 2007–2012.

Breast cancer	Only day shifts (reference) [a]	Ever night shifts [a]					Test for trend P-value I [b]	Test for trend P-value II [c]
	Cases	Cases	Crude RR	95% CI	Adjusted RR [d]	95% CI		
All breast cancer	751	425	0.73	0.65–0.83	0.90	0.80–1.01	0.56	0.10
ER-/HER2-	80	49	0.79	0.56–1.13	0.85	0.59–1.23	0.66	0.46
ER+/HER2-	503	250	0.64	0.55–0.75	0.80	0.68–0.95	0.33	0.05
ER-/HER2+	37	37	1.30	0.82–2.05	1.49	0.93–2.39	0.67	<0.05
ER+/HER2+	55	48	1.13	0.77–1.67	1.26	0.84–1.89	0.18	0.51

[a] The distribution of person years by exposure is shown in supplementary table B (www.sjweh.fi/index.php?page=data-repository).
[b] Test for trend by number of night shifts among night shift workers, adjusted P-value. See supplementary table B for definition of night shift categories.
[c] Test for trend by number of night shifts among night and day shift workers.
[d] Poisson regression model adjusted for calendar year, age, age at birth of first child, number of births, family history of breast cancer or ovarian cancer, oral contraception, hormone replacement therapy, other sex hormones, medication related to alcoholism, mammography screening attendance, and highest family educational level. For details, refer to the text.

Table 3. Rate ratios (RR) and 95% confidence intervals (95% CI) of all breast cancer by night shifts during the past 1 to 1–5 years time windows. Results from female employees of the Danish public sector 2008–2012.

Time window	Only day shifts (reference)		Ever night shifts						Test for trend P-value I [a]	Test for trend P-value II [b]
	Person years	Cases	Person years	Cases	Crude RR	95% CI	Adjusted RR [c]	95% CI		
Past 1 year	399 092	748	181 375	220	0.64	0.55–0.74	0.80	0.89–0.93	0.39	0.01
Past 1–2 years	465 255	822	160 800	218	0.84	0.54–1.30	0.89	0.72–1.10	0.64	0.04
Past 1–3 years	192 055	397	123 451	170	0.67	0.56–0.80	0.83	0.69–1.00	0.87	0.04
Past 1–4 years	110 486	240	80 153	110–114 [d]	0.64	0.51–0.80	0.80	0.64–1.01	0.87	0.05
Past 1–5 years	43 611	113	35 783	69	0.75	0.56–1.01	0.97	0.71–1.32	0.62	0.70

[a] Test for trend by mean number of night shifts during the specified time interval among night shift workers, adjusted p value. See supplementary table C (www.sjweh.fi/index.php?page=data-repository) for definition of night shift categories.
[b] Test for trend by mean number of night shifts during the specified time interval among night shift and day shift workers, adjusted P-value.
[c] Poisson regression model adjusted for calendar year, age, age at birth of first child, number of births, family history of breast cancer or ovarian cancer, oral contraception, hormone replacement therapy, other sex hormones, medication related to alcoholism, mammography screening attendance, and highest family educational level. For details, refer to the text.
[d] According to the data confidentiality policy of Statistics Denmark no less than 4 cases per cell must be reported. Providing the exact total here would allow the calculation of cases in cells with less than 4 cases in supplementary table C (www.sjweh.fi/index.php?page=data-repository).

Table 4. Rate ratios (RR) and 95% confidence intervals (95% CI) of all breast cancer by night shift work since entry and during the past 1 to 1–4 years time windows. Results from female employees from the inception population with first recorded employment in the Danish public sector 2008–2012.

Time window	Only day shifts (reference)		Ever night shifts					
	Person years	Cases	Person years	Cases	Crude RR	95% CI	Adjusted RR [a]	95% CI
Since entry	116 823	144	71 113	69	0.77	0.58–1.03	0.88	0.66–1.17
Past 1 year	98 747	128	40 208	37	0.69	0.48–0.98	0.82	0.56–1.18
Past 1–2 years	60 066	78	31 217	36	0.89	0.60–1.33	1.14	0.76–1.71
Past 1–3 years	30 965	43	18 828	29	1.13	0.71–1.81	1.33	0.82–2.17
Past 1–4 years	10 547	15	7390	10	0.96	0.43–2.14	1.01	0.44–2.32

[a] Poisson regression model adjusted for calendar year, age, age at birth of first child, number of births, family history of breast cancer or ovarian cancer, oral contraception, hormone replacement therapy, other sex hormones, medication related to alcoholism, mammography screening attendance, and highest family educational level. For details, refer to the text.

Discussion

In this large population of women with a high prevalence of night shift work, we observed no elevated risk of all breast cancer following recent night shift work. Modestly increased risks were suggested for HER2+ but not for HER2- breast cancer subtypes irrespective of ER status, but these findings were based on relatively few observations.

We could not corroborate a short-term effect of night shift work on the risk of breast cancer as suggested by experimental data (10, 16). This finding is consistent with that of Fritschi et al (20) and Pesch et al (18) who observed no elevated risk among women working night shifts within the recent ten years [odds ratios (OR) 1.02, 95% CI 0.73–1.43 and 1.04, 95% CI 0.31–3.53, respectively]. However, our findings are not consistent with the findings of Davis et al who observed a slightly elevated risk during the recent ten years of night shift work (OR 1.6, 95% CI 1.0–2.5) (19). As opposed to our study, these studies relied on self-reported information on night shift work and had limited statistical power.

The association between night shift work and HER2+ breast cancer has been examined in three previous studies. Wang et al (28), Papantoniou et al (31), and Cordina-Duverger et al (29) all suggested increased associations between HER2+ tumors and night shift work (OR 1.35, 95% CI 0.94–1.94; OR 1.31, 95% CI 0.93–1.85; and OR 1.91, 95% CI 1.09–3.33, respectively). Cordina-Duverger et al cross classified HER2 and hormone receptor status as we did and observed an OR of 2.52 (95% CI 1.36–4.68) for HER2+ in combination with ER+ or PR+ but no association for HER2+ in combination with ER- or PR- receptor status (OR 0.75, 95% CI 0.16–3.38) and were thus only partly in agreement with our findings (29). ER+/HER2- tumors constituted 88% of the ER+ tumors in this material and the decreased risk we observed for this subtype is not supportive of earlier studies showing associations between night shift work and ER+ tumors (without information on HER2 receptor status) (25–28). Experimental studies implicate melatonin suppression in HER2+ carcinogenesis (45, 46).

The increasing and decreasing trends observed by cumulative and average number of night shifts were only seen when day workers were included as a null-exposed category in the trend tests and not when tested among night shift workers only. This points more towards a night shift worker effect than an effect of night shift work per se.

Strengths and limitations

A major strength of this study was the objective and detailed day-to-day information on working hours from a payroll register that is presumed to be complete for the years 2007–2012. Since the salary varies by working hours during the day and week, these recordings are expected to be precise and valid given that employers and employees have a common interest in correct recordings. We did not have access to information that made validation of the payroll data possible but a recent evaluation of comparable Finnish payroll data showed that the retrieved register data matched originally published shift plans (47).

The detailed work hour data allowed us to define a reference category of only day shifts that included no early morning or late evening shifts that could have affected circadian regulation and thus diluted a possible effect of night shifts. We observed no association between ever non-day, non-night shifts, and breast cancer.

Cases of breast cancer were identified in national registers encompassing all breast cancers diagnosed in Denmark since 1943 and information on HER2 and ER receptor status was recorded for a high proportion of cases (33, 34). Thus, because we relied only on registers with high coverage and completeness and no self-reports, information bias is unlikely.

Based on the extensive register data, we were able to account for major reproductive factors, hormonal treatment, and family history of breast cancer, which are all well-established risk factors for breast cancer.

During recent years, the possible risk of breast cancer following night shift work has attracted public interest in Denmark (48). For that reason, night shift workers may have been more willing to participate in breast cancer screening programs and thus more likely to be diagnosed with breast cancer than day workers. We had access to national mammography screening data and could therefore also adjust for this possible confounder.

We used prescription of medications related to alcoholism as a surrogate measure for alcohol consumption (involving about 1–2% of the population). This will to some extent account for severe alcohol consumption.

Income was not expected to vary substantially in this rather homogenous study population, and therefore we adjusted for the highest education in the family as a surrogate measure for socioeconomic status.

There were also limitations. Several epidemiological studies have observed an increased risk of breast cancer following long-term night shift work that we were not able to assess due to lack of work schedule data prior to 2007 (18, 25, 27, 49–52). An unknown part of the cohort subjects employed during 2007–2012 were hired prior to 2007 where we have no information on working time. They may represent a subset less susceptible to the effects of night shift work. Such left truncation bias is expected to provide underestimates of risk and could explain our decreased risks in several of the analyses (53). We therefore defined an inception population with no recorded employment during a one-year washout period in 2007 that included one third of the total population. Results from this population should not be affected to the same extent by left truncation bias by previous night shift work. However, the results were in line with those from the total study population, but based on small numbers. It should, however, be stressed that the mean age of the inception population was 35.5 years which implies that many have had employment prior to 2007, with and without night shift work.

Long-term night shift work beginning prior to 2007 could have confounded our findings for recent night shift work, if causally related with breast cancer. But this should only be the case if recent night shift work is inversely associated with long-term night shift work. In our opinion, this is perhaps an unlikely explanation.

We were not able to account for chronotype or diurnal preference, alcohol habits in the lower and average end, age at menarche and menopause, obesity, and physical activity, all well-documented risk factors for breast cancer and potential confounders. Previous studies on night shift work and breast cancer have only reported minor confounding effects from these exposures, if any (54).

Although the study population is large, the amount of exposed person time was small in several of the subanalyses and the statistical power thus limited.

Concluding remarks

We observed no increased risk of all breast cancer following recent night shift work. A modestly increased risk was suggested for breast cancer subtypes characterized by positive HER2 status. These findings do not support an overall short-term effect of night shift work. Future studies should explore further the impact of HER2 status.

From a policy perspective, these results are reassuring for the many women working night shifts, but only in the short run. It is still unclear if night shift work effects long-term breast cancer risk or the risk of breast cancer subtypes.

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References

1. Straif K, Baan R, Grosse Y, Secretan B, El Ghissassi F, Bouvard V et al. Carcinogenicity of shift-work, painting, and fire-fighting. Lancet Oncol. 2007;8(12):1065–6. http://dx.doi.org/10.1016/S1470-2045(07)70373-X.

2. Ijaz S, Verbeek J, Seidler A, Lindbohm ML, Ojajarvi A, Orsini N et al. Night-shift work and breast cancer--a systematic review and meta-analysis. Scand J Work Environ Health. 2013 1;39(5):431–47.

3. Jia Y, Lu Y, Wu K, Lin Q, Shen W, Zhu M et al. Does night work increase the risk of breast cancer? A systematic review and meta-analysis of epidemiological studies. Cancer Epidemiol. 2013;37(3):197–206. http://dx.doi.org/10.1016/j.canep.2013.01.005.

4. Kamdar BB, Tergas AI, Mateen FJ, Bhayani NH, Oh J. Night-shift work and risk of breast cancer: A systematic review and meta-analysis. Breast Cancer Res Treat. 2013;138(1):291–301. http://dx.doi.org/10.1007/s10549-013-2433-1.

5. Wang F, Yeung KL, Chan WC, Kwok CC, Leung SL, Wu C et al. A meta-analysis on dose-response relationship between night shift work and the risk of breast cancer. Ann Oncol. 2013;24(11):2724–32. http://dx.doi.org/10.1093/annonc/mdt283.

6. Tamarkin L, Cohen M, Roselle D, Reichert C, Lippman M, Chabner B. Melatonin inhibition and pinealectomy enhancement of 7,12-dimethylbenz(a)anthracene-induced mammary tumors in the rat. Cancer Res. 1981;41(11 Pt 1):4432–6.

7. Anisimov VN, Popovich IG, Zabezhinski MA. Melatonin

and colon carcinogenesis: I. inhibitory effect of melatonin on development of intestinal tumors induced by 1,2-dimethylhydrazine in rats. Carcinogenesis. 1997;18(8):1549–53. http://dx.doi.org/10.1093/carcin/18.8.1549.

8. Cini G, Coronnello M, Mini E, Neri B. Melatonin's growth-inhibitory effect on hepatoma AH 130 in the rat. Cancer Lett. 1998;125(1-2):51–9. http://dx.doi.org/10.1016/S0304-3835(97)00480-1.

9. Reiter RJ. Mechanisms of cancer inhibition by melatonin. J Pineal Res. 2004;37(3):213–4. http://dx.doi.org/10.1111/j.1600-079X.2004.00165.x.

10. Cos S, Gonzalez A, Guezmes A, Mediavilla MD, Martinez-Campa C, Alonso-Gonzalez C et al. Melatonin inhibits the growth of DMBA-induced mammary tumors by decreasing the local biosynthesis of estrogens through the modulation of aromatase activity. Int J Cancer. 2006;118(2):274–8. http://dx.doi.org/10.1002/ijc.21401.

11. Blask DE, Dauchy RT, Brainard GC, Hanifin JP. Circadian stage-dependent inhibition of human breast cancer metabolism and growth by the nocturnal melatonin signal: Consequences of its disruption by light at night in rats and women. Integr Cancer Ther. 2009;8(4):347–53. http://dx.doi.org/10.1177/1534735409352320.

12. Stevens RG. Light-at-night, circadian disruption and breast cancer: Assessment of existing evidence. Int J Epidemiol. 2009;38(4):963–70. http://dx.doi.org/10.1093/ije/dyp178.

13. Fritschi L, Glass DC, Heyworth JS, Aronson K, Girschik J et al. Hypotheses for mechanisms linking shiftwork and cancer. Med Hypotheses. 2011;77(3):430–6. http://dx.doi.org/10.1016/j.mehy.2011.06.002.

14. Proietti S, Cucina A, Reiter RJ, Bizzarri M. Molecular mechanisms of melatonin's inhibitory actions on breast cancers. Cell Mol Life Sci. 2013;70(12):2139–57. http://dx.doi.org/10.1007/s00018-012-1161-8.

15. Blask DE, Brainard GC, Dauchy RT, Hanifin JP, Davidson LK, Krause JA et al. Melatonin-depleted blood from premenopausal women exposed to light at night stimulates growth of human breast cancer xenografts in nude rats. Cancer Res. 2005;65(23):11174–84. http://dx.doi.org/10.1158/0008-5472.CAN-05-1945.

16. Blask DE, Hill SM, Dauchy RT, Xiang S, Yuan L, Duplessis T et al. Circadian regulation of molecular, dietary, and metabolic signaling mechanisms of human breast cancer growth by the nocturnal melatonin signal and the consequences of its disruption by light at night. J Pineal Res. 2011;51(3):259–69. http://dx.doi.org/10.1111/j.1600-079X.2011.00888.x.

17. Hill SM, Frasch T, Xiang S, Yuan L, Duplessis T, Mao L. Molecular mechanisms of melatonin anticancer effects. Integr Cancer Ther. 2009;8(4):337–46. http://dx.doi.org/10.1177/1534735409353332.

18. Pesch B, Harth V, Rabstein S, Baisch C, Schiffermann M, Pallapies D et al. Night work and breast cancer - results from the german GENICA study. Scand J Work Environ Health. 2010;36(2):134–1. http://dx.doi.org/10.5271/sjweh.2890.

19. Davis S, Mirick DK, Stevens RG. Night shift work, light at night, and risk of breast cancer. J Natl Cancer Inst. 2001;93(20):1557–62. http://dx.doi.org/10.1093/jnci/93.20.1557.

20. Fritschi L, Erren TC, Glass DC, Girschik J, Thomson AK, Saunders C et al. The association between different night shiftwork factors and breast cancer: A case-control study. Br J Cancer. 2013;109(9):2472–80. http://dx.doi.org/10.1038/bjc.2013.544.

21. Anderson KN, Schwab RB, Martinez ME. Reproductive risk factors and breast cancer subtypes: A review of the literature. Breast Cancer Res Treat. 2014;144(1):1–10. http://dx.doi.org/10.1007/s10549-014-2852-7.

22. Althuis MD, Fergenbaum JH, Garcia-Closas M, Brinton LA, Madigan MP, Sherman ME. Etiology of hormone receptor-defined breast cancer: A systematic review of the literature. Cancer Epidemiol Biomarkers Prev. 2004;13(10):1558–68.

23. Ma H, Bernstein L, Pike MC, Ursin G. Reproductive factors and breast cancer risk according to joint estrogen and progesterone receptor status: a meta-analysis of epidemiological studies. Breast Cancer Res; 2006;8:1465–542.

24. Papantoniou K, Kogevinas M. Shift work and breast cancer: Do we need more evidence and what should this be? Occup Environ Med. 2013;70(12):825–6. http://dx.doi.org/10.1136/oemed-2013-101630.

25. Schernhammer ES, Laden F, Speizer FE, Willett WC, Hunter DJ, Kawachi I et al. Rotating night shifts and risk of breast cancer in women participating in the nurses' health study. J Natl Cancer Inst. 2001;93(20):1563–8. http://dx.doi.org/10.1093/jnci/93.20.1563.

26. Lie JA, Kjuus H, Zienolddiny S, Haugen A, Kjaerheim K. Breast cancer among nurses: Is the intensity of night work related to hormone receptor status? Am J Epidemiol. 2013;178(1):110–7. http://dx.doi.org/10.1093/aje/kws428.

27. Grundy A, Richardson H, Burstyn I, Lohrisch C, SenGupta SK, Lai AS et al. Increased risk of breast cancer associated with long-term shift work in canada. Occup Environ Med. 2013;70(12):831–8. http://dx.doi.org/10.1136/oemed-2013-101482.

28. Wang P, Ren FM, Lin Y, Su FX, Jia WH, Su XF et al. Night-shift work, sleep duration, daytime napping, and breast cancer risk. Sleep Med. 2015;16(4):462–8. http://dx.doi.org/10.1016/j.sleep.2014.11.017.

29. Cordina-Duverger E, Koudou Y, Truong T, Arveux P, Kerbrat P, Menegaux F et al. Night work and breast cancer risk defined by human epidermal growth factor receptor-2 (HER2) and hormone receptor status: A population-based case-control study in france. Chronobiol Int. 2016;33(6):783–7. http://dx.doi.org/10.3109/07420528.2016.1167709.

30. Rabstein S, Harth V, Pesch B, Pallapies D, Lotz A, Justenhoven C et al. Night work and breast cancer estrogen receptor status--results from the german GENICA study. Scand J Work Environ Health. 2013;39(5):448–55. http://dx.doi.org/10.5271/sjweh.3360.

31. Papantoniou K, Castano-Vinyals G, Espinosa A, Aragones N, Perez-Gomez B, Ardanaz E et al. Breast cancer risk and night shift work in a case-control study in a spanish population. Eur J Epidemiol. 2016;31(9):867–78. http://dx.doi.org/10.1007/s10654-015-0073-y.

32. Schmidt M, Pedersen L, Sorensen HT. The Danish civil registration system as a tool in epidemiology. Eur J Epidemiol. 2014;29(8):541–9. http://dx.doi.org/10.1007/s10654-014-9930-3.

33. Andersen KW, Mouridsen HT. Danish breast cancer cooperative group (DBCG). A description of the register of the nation-wide programme for primary breast cancer. Acta Oncol. 1988;27(6A):627–47. http://dx.doi.org/10.3109/02841868809091763.

34. Gjerstorff ML. The Danish cancer registry. Scand J Public Health. 2011;39(7 Suppl):42–5. http://dx.doi.org/10.1177/1403494810393562.

35. Kildemoes HW, Sorensen HT, Hallas J. The Danish national prescription registry. Scand J Public Health. 2011;39(7 Suppl):38–41. http://dx.doi.org/10.1177/1403494810394717.

36. Baadsgaard M, Quitzau J. Danish registers on personal income and transfer payments. Scand J Public Health. 2011;39(7 Suppl):103–5. http://dx.doi.org/10.1177/1403494811405098.

37. Langagergaard V, Garne JP, Vejborg I, Schwartz W, Bak M, Lernevall A et al. Existing data sources for clinical epidemiology: The Danish quality database of mammography screening. Clin Epidemiol. 2013;5:81–8. http://dx.doi.org/10.2147/CLEP.S40484.

38. Wolff AC, Hammond ME, Hicks DG, Dowsett M, McShane LM, Allison KH et al. Recommendations for human epidermal growth factor receptor 2 testing in breast cancer: American society of clinical Oncology/College of american pathologists clinical practice guideline update. Arch Pathol Lab Med. 2014;138(2):241–56. http://dx.doi.org/10.5858/arpa.2013-0953-SA.

39. Stevens RG, Hansen J, Costa G, Haus E, Kauppinen T, Aronson KJ et al. Considerations of circadian impact for defining 'shift work' in cancer studies: IARC working group report. Occup Environ Med. 2011;68(2):154–62. http://dx.doi.org/10.1136/oem.2009.053512.

40. IARC. World Cancer Report 2008. Lyon: International Agency for Research on Cancer (IARC); 2008.

41. Lacey JV,Jr, Kreimer AR, Buys SS, Marcus PM, Chang SC, Leitzmann MF. Prostate, Lung, Colorectal and Ovarian (PLCO) Cancer Screening Trial Project Team. Breast cancer epidemiology according to recognized breast cancer risk factors in the prostate, lung, colorectal and ovarian (PLCO) cancer screening trial cohort. BMC Cancer. 2009;9:84,2407–9-84.

42. Ryu EB, Chang JM, Seo M, Kim SA, Lim JH, Moon WK. Tumour volume doubling time of molecular breast cancer subtypes assessed by serial breast ultrasound. Eur Radiol. 2014;24(9):2227–35. http://dx.doi.org/10.1007/s00330-014-3256-0.

43. Peer PG, van Dijck JA, Hendriks JH, Holland R, Verbeek AL. Age-dependent growth rate of primary breast cancer. Cancer. 1993;71(11):3547–51. http://dx.doi.org/10.1002/1097-0142(19930601)71:11<3547::AID-CNCR2820711114>3.0.CO;2-C.

44. Tilanus-Linthorst MM, Obdeijn IM, Hop WC, Causer PA, Leach MO, Warner E et al. BRCA1 mutation and young age predict fast breast cancer growth in the dutch, united kingdom, and canadian magnetic resonance imaging screening trials. Clin Cancer Res. 2007;13(24):7357–62. http://dx.doi.org/10.1158/1078-0432.CCR-07-0689.

45. Mao L, Yuan L, Slakey LM, Jones FE, Burow ME, Hill SM. Inhibition of breast cancer cell invasion by melatonin is mediated through regulation of the p38 mitogen-activated protein kinase signaling pathway. Breast Cancer Res. 2010;12(6):R107. http://dx.doi.org/10.1186/bcr2794.

46. Anisimov VN, Alimova IN, Baturin DA, Popovich IG, Zabezhinski MA, Manton KG et al. The effect of melatonin treatment regimen on mammary adenocarcinoma development in HER-2/neu transgenic mice. Int J Cancer. 2003;103(3):300–5. http://dx.doi.org/10.1002/ijc.10827.

47. Harma M, Ropponen A, Hakola T, Koskinen A, Vanttola P, Puttonen S et al. Developing register-based measures for assessment of working time patterns for epidemiologic studies. Scand J Work Environ Health. 2015;41(3):268–79. http://dx.doi.org/10.5271/sjweh.3492.

48. Wise J. Danish night shift workers with breast cancer awarded compensation. BMJ. 2009;338:b1152. http://dx.doi.org/10.1136/bmj.b1152.

49. Hansen J, Lassen CF. Nested case-control study of night shift work and breast cancer risk among women in the danish military. Occup Environ Med. 2012;69(8):551–6. http://dx.doi.org/10.1136/oemed-2011-100240.

50. Hansen J, Stevens RG. Case-control study of shift-work and breast cancer risk in danish nurses: Impact of shift systems. Eur J Cancer. 2012;48(11):1722–9. http://dx.doi.org/10.1016/j.ejca.2011.07.005.

51. Schernhammer ES, Kroenke CH, Laden F, Hankinson SE. Night work and risk of breast cancer. Epidemiology. 2006;17(1):108–11. http://dx.doi.org/10.1097/01.ede.0000190539.03500.c1.

52. Lie JA, Roessink J, Kjaerheim K. Breast cancer and night work among norwegian nurses. Cancer Causes Control. 2006;17(1):39–44. http://dx.doi.org/10.1007/s10552-005-3639-2.

53. Applebaum KM, Malloy EJ, Eisen EA. Left truncation, susceptibility, and bias in occupational cohort studies. Epidemiology. 2011;22(4):599–606. http://dx.doi.org/10.1097/EDE.0b013e31821d0879.

54. Kolstad HA. Nightshift work and risk of breast cancer and other cancers--a critical review of the epidemiologic evidence. Scand J Work Environ Health. 2008;34(1):5–22. http://dx.doi.org/10.5271/sjweh.1194.

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Response to Dr Stevens' letter ref. Visitisen et al: "Short-term effects of night shift work on breast cancer risk: a cohort study of payroll data"

by Kolstad HA, Garde AH, Hansen ÅM, Frydenberg M, Christiansen P, Vistisen HT, Bonde JPE

Affiliation: Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark. henkol@rm.dk

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Response to Dr Stevens' letter ref. Visitisen et al: "Short-term effects of night shift work on breast cancer risk: a cohort study of payroll data"

We thank Dr Richard Stevens for his comments (1) on our recent article that showed no increased risk of breast cancer following recent night shift work when compared with recent day shift work (2). This finding was based on linkage of day-by-day information on working hours and breast cancer incidence data. Results are thus less likely to have been biased by differential misclassification than findings from earlier studies relying on self-report (3).

We defined a night shift as ≥3 hours of work between 24:00–05:00 hours and a day shift as ≥3 hours work between 6:00–20:00 hours. This day shift definition did not exclude shifts starting before 05:00 or ending after 24:00 hours. However, this affected only 0.02% and 0.3% of all day shifts, respectively. This diminutive misclassification, that is expected to be non-differential, can hardly explain our negative findings.

It is suggested that shifts that begin after 07:00 and end before 18:00 would constitute a more sensible baseline comparison group. Since the biological mechanism is not certain, it is not obvious to us if this will be a more appropriate reference than the present. However, we agree that future studies should test how different definitions of shifts affect the risk of breast cancer, which will be possible using this type of data.

We only had information on working hours from 2007 and onwards, and night shift work prior to 2007 could have confounded our analyses towards no effect but only if inversely associated with night shift work in 2007 or later. We find this unlikely. Left truncation could also have biased findings towards the null. We therefore supplemented analyses of the total study population with analyses of the one-third of the population with first recorded employment in 2008 or later (the inception population). Even if the mean age was 35.5 years – and many undoubtedly had been working (with and without night shifts) prior to 2008 – this population should be less affected by such selection bias, but we observed similar risk estimates as for the total study population.

Taken together, we find that our study provides rather robust evidence of no short-term breast cancer risk following recent night shift work. It must, however, be stressed that data did not allow assessment of a possible long-term risk.

Reference

1. Stevens R. Letter ref. Vitisen et al: "Short-term effects of night shift work on breast cancer risk: a cohort study of payroll data". Scand J Work Environ Health. 2017;43(1):95. http://dx.doi.org/10.5271/sjweh.3607

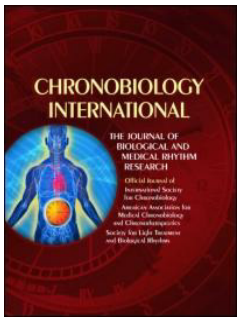
2. Vistisen HT, Garde AH, Frydenberg M, Christiansen P, Hansen AM, Hansen J, Bonde JP, Kolstad HA. Short-term effects of night shift work on breast cancer risk: A cohort study of payroll data. Scand J Work Environ Health. 2017;43(1):59–67. http://dx.doi.org/10.5271/sjweh.3603.

3. Ijaz S, Verbeek J, Seidler A, Lindbohm ML, Ojajarvi A, Orsini N, Costa G, Neuvonen K. Night-shift work and breast cancer--a systematic review and meta-analysis. Scand J Work Environ Health. 2013 Sep 1;39(5):431-47. http://dx.doi.org/10.5271/sjweh.3371

Henrik A Kolstad, MD, [1] Anne Helene Garde, PhD,[2] Åse Marie Hansen, PhD,[2, 3] Morten Frydenberg, PhD,[4] Peer Christiansen, MD,[5, 6] Helene Tilma Vistisen, PhD,[1] Jens Peter E Bonde, MD,[7]

1 Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark.
2 National Research Centre for the Working Environment, Copenhagen, Denmark.
3 Department of Public Health, University of Copenhagen, Copenhagen, Denmark.
4 Section for Biostatistics, Department of Public Health, Aarhus University, Aarhus, Denmark.
5 Department of Breast Surgery, Aarhus University Hospital, Aarhus, Denmark.
6 Danish Breast Cancer Corporative Group (DBCG). http://www.dbcg.dk/
7 Department of Occupational and Environmental Medicine, Bispebjerg University Hospital, Copenhagen, Denmark.

Correspondence to: Henrik A Kolstad, Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark. [E-mail:henkol@rm.dk].



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Night work, light exposure and melatonin on work days and days off

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Night work, light exposure and melatonin on work days and days off

Stine Daugaard[a], Anne Helene Garde[b,d], Jens Peter Ellekilde Bonde[c,d], Jens Christoffersen[e], Åse Marie Hansen[b,d], Jakob Markvart[f], Vivi Schlünssen[b,g], Debra J. Skene[h], Helene Tilma Vistisen[a,i] and Henrik A. Kolstad[a]

[a]Aarhus University Hospital, Department of Occupational Medicine, Aarhus, Denmark; [b]National Research Centre for the Working Environment, Copenhagen, Denmark; [c]Bispebjerg Hospital, Department of Occupational Medicine, Copenhagen, Denmark; [d]University of Copenhagen, Institute of Public Health, Copenhagen, Denmark; [e]Velux Danmark A/S, Stakeholder Communications and SustanabilityHorsholm, Denmark; [f]Aalborg Universitet, Department of Energy Performance, Indoor Environment and Sustainability, Danish Building Research Institute, Copenhagen, Denmark; [g]Aarhus Universitet, Department of Public Health, Aarhus, Denmark; [h]University of Surrey, Faculty of Health and Medical Sciences, Chronobiology, Guildford GU2 7XH, Surrey, United Kingdom; [i]Aarhus University Hospital, Aarhus, Denmark

ABSTRACT

We aimed to examine the effects of night work on salivary melatonin concentration during and subsequent to night work and the mediating role of light. We included 254 day workers and 87 night workers who were followed during 322 work days and 301 days off work. Each day was defined as the 24 hour period starting from the beginning of a night shift or from waking in the mornings with day work and days off. Light levels were recorded and synchronized with diary information (start and end of sleep and work). On average, participants provided four saliva samples per day, and these were analyzed for melatonin concentration by liquid chromatography tandem mass spectrometry (LC-MS/MS). Differences between day and night workers on work days and days off were assessed with multilevel regression models with melatonin concentration as the primary outcome. All models were stratified or adjusted by time of day. For light exposure, we estimated the total, direct and indirect effects of night work on melatonin concentrations obtaining 95% confidence intervals through bootstrapping. On work days, night workers showed 15% lower salivary melatonin concentrations compared with day workers (−15.0%; 95% CI: −31.4%; 5.2%). During the night, light exposure mediated a melatonin suppression of approximately 6% (−5.9%, 95% CI: −10.2%; −1.5%). No mediating effect of light was seen during the day time. On days off, we observed no difference in melatonin concentrations between day and night workers. These findings are in accordance with a transient and partly light-mediated effect of night work on melatonin production.

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Introduction

Epidemiological studies have suggested increased risk of breast cancer following shift work (Kolstad, 2008; Lin et al., 2015; Wang et al., 2013). A recent meta-analysis of 10 follow-up studies found little or no effect on breast cancer incidence (Travis et al., 2016). However, previous epidemiological studies have some methodological limitations making interpretation of the results difficult. Yet, a working group convened by the International Agency for Research on Cancer (IARC) in 2007 classified shift work that involves circadian disruption, as probably carcinogenic to humans based on sufficient evidence in animals and limited evidence in humans (Straif et al., 2007).

Light exposure during night shifts and suppression of melatonin synthesis has been hypothesized as pivotal causal elements linking shift work and cancer (Costa et al., 2010; Schernhammer & Schulmeister, 2004; Stevens et al., 2014). Melatonin is a circadian hormone produced primarily by the pineal gland during the night. Production peaks around 02:00 h in humans entrained to the ambient 24-hour light/dark cycle (Skene & Arendt, 2006). Melatonin may have oncostatic effects through various pathways such as inhibition of tumor growth, reduction of oxidative DNA damage or change of estrogen levels (Hill et al., 2015).

During work days, the majority of field studies have observed lower salivary melatonin or urinary 6-sulfatoxymelatonin (aMT6s, the major melatonin metabolite) concentrations in night workers compared with day workers (Davis et al., 2012; Gómez-Acebo et al., 2015; Hansen et al., 2006; Leung et al.,

CONTACT Stine Daugaard stepde@rm.dk Nørrebrogade 44, Building 2C, 8000 Aarhus C, Denmark.
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2016; Mirick et al., 2013; Papantoniou et al., 2014;; Schernhammer et al., 2004), but this was not observed in all studies (Peplonska et al., 2012). Comparisons within night workers have shown lower (Jensen et al., 2016; Leung et al., 2016; Mirick et al., 2013; Yamauchi, 2004) or similar (Dumont et al., 2012; Gibbs et al., 2007; Grundy et al., 2011) melatonin or aMT6s levels on days with night work compared to days with day work. Studies including day and night workers during work days and days off found lower urinary aMT6s levels in night workers, compared with day workers on work days as well as during the first night sleep period after a night shift (Davis et al., 2012; Mirick et al., 2013), and this has also been found during the second day after a night shift (Hansen et al., 2006). Melatonin production was thus still affected 12–36 hours after completing a night shift. However, a recent study measuring salivary melatonin found full recovery of the melatonin profile on the second day off (Jensen et al., 2016).

From laboratory studies it is well established that retinal exposure to polychromatic light at night acutely suppresses melatonin concentration depending on intensity, duration and spectrum of the light with substantial inter-individual variation of the effect (Bojkowski et al., 1987; Figueiro et al., 2006a; Rea & Figueiro, 2014; Rea et al., 2005; Revell & Skene, 2007).

Average and median light levels measured at shoulder or neck level during night shifts have been reported below 80 lux among health care and industrial workers (Borugian et al., 2005; Dumont et al., 2012; Grundy et al., 2011; Papantoniou et al., 2014). These averaged levels are expected to have relatively low impact on melatonin synthesis (Figueiro et al., 2006a). The response to light also depends on peak exposures, the individual and their photic history (Burgess & Fogg, 2008; Hebert et al., 2002).

Few field studies have included objective measures of light at night when studying melatonin production during night work. Papantoniou et al. (2014) found that night workers in the highest tertile of light exposure during night work had lower 24-h aMT6 than the lowest tertile. Dumont et al. (2012) made similar observations, but they did not observe an association between light at night and melatonin production during night. Grundy et al. (2011) observed no consistent association between light exposure and melatonin production among nurses working rapidly rotating shifts. As far as we are aware, no field studies have analyzed to what extent light exposure mediates the effect of night work on melatonin levels.

The objectives of the current study were to examine melatonin concentrations during and subsequent to night work and the mediating role of light exposure.

Materials and methods

Population

Participants were recruited through employers, advertisements and via the homepage of the National Research Centre for the Working Environment. The aim was to recruit equal numbers of indoor day workers, outdoor day workers and night workers. Enrolment of participants took place at two centers (Aarhus, latitude 56°90′N longitude 20°12′E and Copenhagen, latitude 55°40′N longitude 12°34′E). In total, 535 subjects participated and 404 (76%) collected saliva samples. The study was carried out from March 2012 to May 2013. All participants gave written informed consent, and the study was approved by the Danish Data Protection Agency (J.nr. 2011–41-6850) and the Regional Ethics Committee (M-20110214) in Denmark.

For the present study, five participants were excluded due to pregnancy which may alter melatonin metabolism (Kivela, 1991; Lew, 1987). Fifty-eight rotating night workers were excluded as they did not provide saliva samples during days with night work. The study population thus comprised 341 participants (64%), hereof 87 night workers and 254 day workers. The night workers were defined as those working more than three hours between 00:00 h and 05:00 h on a regular (n = 19) or a rotating basis (n = 68) (Stevens et al., 2011). Day workers were a mix of indoor and outdoor workers who never worked between 00:00 h and 05:00 h.

The night workers were hospital employees (n = 75), factory workers (n = 10) or residential social workers (n = 2). The day workers were nursery workers (n = 61), hospital employees (n = 56), teachers (n = 47), gardeners and pavers (n = 34), factory workers (n = 18), craftsmen (n = 13), mechanics (n =

8), office workers (n = 8), dentist or dental assistants (n = 7) or residential social workers (n = 2).

Light exposure assessment

Light levels and actigraphy (movement counts) were recorded for seven consecutive days with a Philips Respironics Actiwatch Spectrum (Actiwatch). The Actiwatch was worn outside clothes on the upper arm. During sleep, the Actiwatch was placed next to the bed except for two sleep periods where it was worn on the wrist for sleep measures (not reported here). The Actiwatch was set to one-minute sampling epochs and recorded white light (lux). After data collection was completed, the light sensor outputs from the Actiwatches were calibrated as described by Markvart et al. (Markvart et al., 2015).

Light measurements were synchronized with diary information on the start and end of sleep and work. In the diary, each participant reported if they had worn the Actiwatch for less than 20 minutes within every hour. If the participant did not report wearing the Actiwatch, or the Actiwatch recorded no movement for 20 consecutive minutes, we inspected the light and actigraphy measurements and assessed if the light recordings should be included or not. Light measurements were excluded if there was no movement, or a constant light level was recorded.

In laboratory studies, melatonin production was not suppressed by polychromatic light intensities below 80 lux (Zeitzer et al., 2000), and suppression has been shown to occur within 30 minutes of light exposure (Bojkowski et al., 1987; Revell & Skene, 2007; Thapan et al., 2001). Comparable thresholds have been reported by other studies (Figueiro et al., 2006a, 2006b). We therefore classified light exposure by the duration of light exposure above 80 lux occurring 30 minutes before each saliva sample (0–30 minutes).

Questionnaire and diary

The questionnaire included information on sex, age (years), pregnancy (current yes/no), occupation (current), height (centimetres), weight (current kilograms), smoker (current, former or never), use of melatonin supplementation (yes/no), antidepressant medications (yes/no) and diurnal preference (response categories: definitely a morning person, more a morning person than an evening person, more an evening person than a morning person, definitely an evening person). Three night workers and two day workers reported occasional use of melatonin supplementation. Their melatonin profiles were inspected, and none of them indicated the presence of exogenous melatonin administration.

The diary recorded the start and end of sleep and work, whether the day was a work day or a day off work, and if the Actiwatch was worn for less than 20 minutes within every hour of the day.

Collection of saliva and assessment of melatonin

For each participant, we aimed at including saliva samples during one work day (a day with night work or a day with day work) and a day off. The participants decided themselves on which days in the 7-day study period to collect saliva. Participants were instructed to collect the first sample at the first awakening from their primary sleep. Following the first sample, participants were asked to collect saliva at 07:00 h, 11:00 h, 15:00 h, 19:00 h, 23:00 h and 03:00 h when awake. An additional sample was collected just before bedtime. Night workers followed the same instructions, but on days with night work sampling started in the afternoon at awakening, and the next sample was collected at 15:00 h or 19:00 h, depending on waking time. The sampling period ended the following morning, when night workers went to bed. Eating was not allowed 30 minutes prior to sampling. The sampling tube should contain approximately 1 ml saliva. No instructions were given on light conditions when sampling. Just after sample collection participants noted the date and exact time on a label on the saliva tube and stored the sample at 5°C whenever possible until the end of the 7-day study period. Melatonin in saliva is stable at room temperature for at least seven days (Jensen et al., 2011).

Samples from day workers were classified as work day measurements if sampled within 24 hours after awakening on a work day. Samples from night workers were classified as work day measurements if sampled within 24 hours after the beginning of a night shift. Samples from day workers obtained within 24 hours after awakening on a day off were classified as day off samples. Samples from night workers were classified as day off samples according the same criteria as the day workers but in addition requested that

samples should be obtained more than 24 hours after ending a night shift. This additional criterion was included to obtain a well defined day off category.

In total, 3579 saliva samples were collected. We excluded 430 saliva samples from rotating night workers during days with day shift, 47 samples without valid light measurements, 45 samples from pregnant participants, four samples above and 14 samples below three standard deviations (636 nmol/L and 0.4 nmol/L) of the geometric mean of all samples according to Grubb's outlier test (Grubbs, 1950), 34 samples obtained on a day off less than 24 hours after the end of a night shift and 161 samples from night workers before the beginning of their first night shift, leaving 2842 samples for analyses. A total of 1541 saliva samples were collected on 322 work days, and 1301 saliva samples were collected on 301 days off (Table 1. Of the night workers, 44 (50%) collected saliva samples during the day of the first night shift, 38 (44%) during the day of the second night shift and five (6%) during the day of the third to fifth night shift during the follow up period. On average the night workers day off, saliva samples were provided 47 hours (range 25–116 hours) after the end of the last night shift.

Melatonin analyses were carried out using liquid chromatography tandem mass spectrometry (LC-MS/MS) as described in Jensen et al. (Jensen et al., 2011). A volume of 25 µL was injected into an Agilent 1200 HPLC (Agilent technologies, Santa Clara, CA, USA) equipped with a C18 2.1 mm x 50mm 2.6µm Kinetex column (Phenometex, Torrance, CA, USA). A linear gradient was run over 3 minutes from 10% to 100% methanol (MeOH) and kept at 100% for two and a half minutes, followed by one minute of equilibration at 10% MeOH. The mass spectrometer, an Agilent 6460 QQQ equipped with jet stream electrospray ionization (ESI) ion source, was operated in a positive ion mode. The quantification was achieved by using the mass spectrometer in multiple reaction monitoring modes. A single precursor ion-product ion transition was measured for each hormone and its internal standard. The transitions were as follows: m\z 233.2 -> m\z 174.1. The limit of detection (LOD) was 3.73 pmol/L, and 74 samples (2%) had concentrations below LOD. For a concentration below LOD, the sample was given a random number from a normal distribution with 2/3 of the LOD as the mean. To test equivalence between analyses, reference samples at two levels (28–43 pmol/L, intra assay coefficient of variation (CV): 20%; 80–152 pmol/L, CV = 13%) were analyzed with every 14 samples. Westgard control charts (Westgard et al., 1981) were used to document that the LC-MS/MS method remained under statistical and analytical control. Samples that failed analysis were rerun once. If the concentration was above 490 pmol/L, solutions were diluted and reanalysed.

Statistical analysis

Characteristics of the study population were presented as numbers (%), means and range. Light and melatonin concentrations were log normally distributed and were therefore naturally log transformed. Mean levels per 4-hour time intervals and type of worker (day worker, night worker) were calculated and expressed as geometric means with 95% confidence intervals. We compared geometric mean light exposure and duration above 80 lux between day and night workers with Student's t-test. All analyses comparing night and day workers were stratified into work days and days off. Geometric mean melatonin levels by duration of light exposure above 80 lux were computed separately for day (08:00–19:59 h) and night hours (20:00–07:59 h).

We also compared melatonin concentration between day and night workers on work days and days off work with multivariate multilevel linear regression (STATA mixed procedure) to account for the repeated measurements. For each individual, we used a random intercept with a variance component covariance structure and

Table 1. Numbers of participants and saliva samples by type of worker and type of day.

	Day workers		Night workers		Total	
	Participants *N*	Samples *N*	Participants *N*	Samples *N*	Participants *N*	Samples *N*
Work day	235	1204	87	337	322	1541
Day off	230	1021	71	280	301	1301
Total	254	2225	87	617	341	2842

repeated statement for the samples with an autoregressive covariance structure. Type of worker (day worker, night worker) and time of day (01:00–04:59 h, 05:00–08:59 h, 09:00–12:59 h, 13:00–16:59 h, 17:00–20:59 h, 21:00–00:59 h) were included as categorical variables. Potential confounders included were age (continuous, years), sex (male, female), body mass index (BMI, kg/cm^2,calculated as weight/height^2, continuous), current smoking (yes, no), diurnal preference (morning type: definitely a morning person, more a morning person than an evening person, evening type: more an evening person than a morning person, definitely an evening person) and use of antidepressant medication (yes, no). These factors were identified *a priori* based on a review of the literature (Bhatti et al., 2014; Burgess & Fogg, 2008; Leung et al., 2016; Papantoniou et al., 2014; Schernhammer et al., 2006).

To assess if light exposure mediated the effect of night work on melatonin levels, we conducted mediation analyses. These were restricted to work days, since no difference in melatonin concentrations was observed between day and night workers on days off. Work days were stratified into day (08:00–19:59 h) and night hours (20:00–07:59 h) because time of day is a significant modifier of the effect of light. Light exposure was included as duration above 80 lux occurring 30 minutes before each saliva sample. The minimum value was therefore 0 minutes and the maximum 30 minutes.

We estimated the direct, indirect (mediated by light exposure) and total effects of night work with classical path analysis methods combining the results of two regression analyses (Hayes, 2009). Firstly, we regressed log-melatonin on night work, light exposure and covariates. Secondly, we regressed light exposure on night work and covariates:

$$E[\log(melatonin)] = \beta_0 + \beta_{Night\ work} \times Night\ work + \beta_{Light\ exposure} \times Light\ exposure + \beta_{Covariates} \times Covariates$$

$$E[\text{Light exposure}] = \alpha_0 + \alpha_{Night\ work} \times Night\ work + \alpha_{Covariates} \times Covariates$$

The direct effect, indirect and total effects of night work on log-melatonin were then defined as:

$$\text{Direct effect} = \beta_{Night\ work}$$
$$\text{Indirect effect} = \alpha_{Night\ work} \times \beta_{Light\ exposure}$$
$$\text{Total effect} = \beta_{Night\ work} + \alpha_{Night\ work} \times \beta_{Light\ exposure}$$

We estimated 95% confidence intervals using 1000 bootstrap samples. The relative effects of night work (%) on melatonin were found by the exponentials. Note that, as the effects on log melatonin are assumed to be additive/linear, the effects on melatonin are multiplicative/relative.

In a separate internal analysis among night workers only, we examined if night workers' melatonin production was lower on days with night work compared with days off. Analyses that compared permanent night workers only (n =19) with day workers (n =254) were also carried out.

In additional analyses, we included the exact time of saliva sampling in addition to the 4-hour time categories. This only changed estimates marginally and was thus not included in the presented analyses. To examine if melatonin concentrations between day and night workers varied across the day, we included an interaction term between type of worker and 4-hour time intervals of the day. Since the interaction term was not significant in any of the models except for the analyses of the permanent night workers, this was not included in the other models. All statistical analyses were carried out using Stata 13.1 (Stata.corp, TX, USA)

Results

Table 2 presents characteristics of the 254 day workers and 87 night workers. Night workers were younger, more often women, were less often smokers and were more often evening types in their diurnal preference. Almost twice as many night workers as day workers used antidepressant medication. Of the day workers, 26 % had previously worked night shifts.

Table 3 presents geometric mean salivary melatonin concentrations in 4-hour intervals during work days and days off for night and day workers. Night workers' mean melatonin concentrations were lower than day workers at all times of the day except between 01:00 and 04:59 h.

Table 4 presents geometric mean light levels and mean duration of light exposure above 80 lux for day and night workers by time of day during work days

Table 2. Characteristics of the study population (n = 341) and saliva samples (n = 2842).

	Day workers (n = 254)					Night workers (n = 87)				
	Participants *N*	%	Saliva samples *N*	Mean	Range	Participants *N*	%	Saliva samples *N*	Mean	Range
Age	254			44.4	17–68	87			40.6	24–58
BMI (kg/m^2)[a]	247			24.8	16.9–45.3	87			25.3	17.1–42.6
Years of night work[b]	65			4.5	0.25–33	86			12.1	0.5–37
Sex										
Male	83	32.7	709	–	–	8	9.2	55	–	–
Female	171	67.3	1516	–	–	79	90.8	562	–	–
Current smoker										
Yes	40	15.7	307			16	18.4	110		
No	214	84.3	1918			79	81.6	507		
Diurnal preference[c]										
Morning type	159	63.3	1444	–	–	29	33.3	215	–	–
Evening type	92	36.7	754	–	–	58	66.7	402	–	–
Use of antidepressants										
Yes	11	4.5	89	–	–	7	8.8	50	–	–
No	243	95.5	2136	–	–	80	91.2	567	–	–

Number of participants with missing information [a]7, [b]1 [c]3.

and days off. On work days, night workers were exposed to significantly higher light levels than day workers between 21:00 and 05:00 h, and day workers were exposed to significantly higher light levels than night workers between 09:00 and 21:00 h. During days off, similar light levels among night and day workers were observed.

Table 5 presents geometric mean melatonin concentration during the night and day by duration of light exposure above 80 lux occurring in the past 30 minutes. When light exposure lasted more than 10 minutes during the night hours, melatonin concentrations were almost half of the level seen for a shorter light duration. Melatonin concentrations during the day were not affected by light exposure duration.

Table 6 presents crude and adjusted relative difference (%) in melatonin concentration in day workers compared with night workers from the multilevel linear regression analyses. On work days night workers showed 16.5% (95% CI −0.2; −30.5) lower melatonin concentrations than day workers in the adjusted analysis that differed only marginally from the crude analysis. On days off work, no differences in melatonin concentration between night workers and day workers were observed.

Table 7 presents results from the mediation analyses. During night and day, night shift workers showed, respectively, 15.0% and 16.2% (−15.0 % [95% CI: −31.4%; 5.2%] and −16.2 % [95% CI: −34.6%; 7.5%]) lower melatonin concentrations than the day workers (the total effects). During the night, light exposure mediated a 5.9 % decrease (−5.9% [95% CI: −10.2%; −1.5%]) in melatonin levels in the night workers compared with day workers. No mediating effect of light exposure was seen during the day. The direct effects of night work were −9.6% (95% CI −27.0; 11.9) during the night and −18.3% (95% CI −36.7; 5.4) during the day.

Figure 1 shows the adjusted geometric mean melatonin levels in day and night workers by time of day during work days and days off. Results are presented for a male, 40 year old, BMI 25kg/m^2, non-smoker, no antidepressant medication and morning preference. The relative difference between day and night workers on work days did not differ across the day, whereas the absolute difference was largest at night. Night workers' mean melatonin concentrations were lower at all times of a work day compared to a day off. Day workers showed a higher mean melatonin concentration between 05:00 and 08:59 h on work days compared to days off. Apart from this, mean melatonin concentration was similar on work days and days off among day workers.

In the night workers, the difference in adjusted melatonin concentrations between night shifts and days off was −15.4% (95% CI −30.6%; 2.8%), being lower on days with night work compared to days off work (data not shown). On work days, the

Table 3. Geometric mean salivary melatonin concentration by time of day among day and night workers on work days and days off.

	Day workers (N = 254)					Night workers (N = 87)				
Time of day	Mean time of sampling (SD*)	Samples N	Participants N	Geometric mean melatonin concentration (pmol/L)	95% CI	Mean time of sampling (SD*)	Samples N	Participants N	Geometric mean melatonin concentration (pmol/L)	95% CI
Work days										
01:00–04:59	03:03 (80)	29	28	46.1	34.8; 61.0	02:52 (70)	70	68	48.9	38.8; 61.7
05:00–08:59	06:31 (52)	269	212	32.7	29.2; 36.7	07:14 (62)	78	66	26.8	21.2; 33.8
09:00–12:59	10:49 (57)	236	212	10.2	9.1; 11.5	10:54 (75)	25	23	8.1	4.9; 13.2
13:00–16:59	14:51 (57)	224	199	9.2	8.1; 10.5	15:13 (56)	52	47	6.8	5.3; 8.9
17:00–20:59	18:51 (60)	217	188	9.7	8.4; 11.2	18:58 (57)	47	43	8.4	6.2; 11.3
21:00–00:59	22:35 (47)	229	191	35.9	31.7; 40.6	22:52 (70)	65	59	27.7	20.8; 37.0
Total	14:08 (633)	1204	235	17.0	15.9; 18.1	12:30 (445)	337	87	19.3	16.8; 22.1
Days off										
01:00–04:59	02:40 (83)	25	22	54.0	37.9; 75.8	02:34 (74)	8	7	87.2	44.9; 172.2
05:00–08:59	07:17 (57)	188	173	21.4	18.7; 24.6	07:26 (61)	28	27	26.8	17.9; 40.1
09:00–12:59	10:52 (67)	218	197	11.2	9.8; 12.7	10:33 (68)	65	58	13.2	10.1; 17.3
13:00–16:59	14:52 (55)	180	168	9.0	7.8; 10.3	14:34 (61)	61	58	8.0	6.1; 10.5
17:00–20:59	18:50 (56)	204	182	9.5	8.3; 10.9	18:46 (64)	55	53	9.5	7.0; 12.9
21:00–00:59	22:36 (48)	216	175	30.2	26.3; 34.6	22:42 (53)	63	57	26.2	19.6; 34.9
Total	14:42 (351)	1021	230	14.9	13.9; 15.9	15:14 (340)	280	71	14.7	12.7; 16.9

Note. SD* given as minutes.

Table 4. Light exposure levels on day and night workers by time of day on work days and days off. Results are presented as geometric means and durations of light above 80 lux.

	Day workers (*N* = 254)		Night workers (*N* = 87)			Day workers (*N* = 254)		Night workers (*N* = 87)		
Time of day	Geometric mean light exposure (lux)	95% CI	Geometric mean light exposure (lux)	95% CI	*p*–Value*	Mean duration of light above 80 lux (minutes)	95% CI	Mean duration of light above 80 lux (minutes)	95% CI	*p*–Value*
Work days										
01:00–04:59	0.0	0.0; 0.1	6.0	4.6; 7.9	0.000	0.1	0.0; 0.3	24	15; 33	0.000
05:00–08:59	17	13; 20	13	10; 17	0.27	68	62; 74	45	37; 54	0.000
09:00–12:59	194	173; 221	3.6	1.9; 6.8	0.000	166	159; 173	35	20; 50	0.000
13:00 – 16:59	187	158; 212	26	17; 41	0.000	156	147; 163	72	58; 87	0.000
17:00–20:59	27	21; 32	16	11; 22	0.02	76	41; 69	55	67; 84	0.01
21:00–00:59	1.3	0.9; 1.6	6.0	4.9; 7.5	0.000	7	5; 8	18	11; 24	0.000
Days Off										
01:00–04:59	0.0	0.0; 0.1	0.2	0.1; 0.4	0.001	1.1	−0.3; 2.5	0.6	0.1; 1.1	0.75
05:00–08:59	2.2	1.3; 2.7	2.1	1.2; 3.6	0.73	26	21; 31	21	14; 28	0.31
09:00–12:59	152	125; 186	97	71; 134	0.02	141	133; 148	127	113; 141	0.09
13:00 – 16:59	152	118; 186	128	90; 182	0.50	140	131; 148	130	114; 146	0.27
17:00–20:59	24	19; 29	17	12; 24	0.20	69	61; 77	59	45; 72	0.20
21:00–00:59	1.0	0.8; 1.2	2.2	1.7; 2.7	0.001	6	5; 7	5	3; 7	0.27

*Comparison of light exposure between day and night workers by Students t-test.

Table 5. Geometric mean melatonin concentrations by duration of light exposure above 80 lux 30 minutes prior to saliva sampling during night and day.

Time of day	Duration of light exposure above 80 lux	Mean time of sampling (SD*)	Samples *N*	Participants *N*	Geometric mean melatonin concentration (pmol/L)	95% CI
Night 20:00 – 07:59	< 10 min	01:41 (235)	1142	334	31.8	30.0; 33.7
	10–20 min	01:41 (284)	56	47	16.9	12.6; 22.8
	20–30 min	01:32 (295)	50	45	16.7	12.0.; 23.4
	All samples	01:41 (239)	1248	337	30.1	28.4; 31.9
Day 08:00 – 19:59	< 10 min	13:37 (2273)	667	287	10.7	9:9; 11.6
	10–20 min	13:51 (220)	269	188	10.3	9.1; 11.6
	20–30 min	13:42 (183)	658	270	9.2	8.5; 9.8
	All samples	13:42 (231)	1594	334	10.0	9.5; 10.5
Total	< 10 min	13:53 (440)	1809	338	21.3	20.2; 22.4
	10–20 min	13:54 (269)	325	210	11.3	10.0; 12.7
	20–30 min	13:46 (208)	708	279	9.6	8.9; 10.2
	All samples	13:51 (377)	2842	341	16.2	15.5; 16.9

*SD given as minutes.

Table 6. Crude and adjusted relative difference (%) in salivary melatonin concentration in night workers compared with day workers.

			Crude		Adjusted*	
	Samples *N*	Participants *N*	% difference	95% CI	% difference	95% CI
Work days	1541	322	−17.0	−29.1; −1.6	−16.5	−30.5; −0.2
Days off	1301	301	3.2	−12.8; 22.1	8.5	−9.3; 29.8

*Adjusted for time of day, age, sex, BMI, smoking, diurnal preference and use of antidepressant medication.

Table 7. Adjusted[a] total, direct, and indirect effects of light exposure[b] on the association of night work with salivary melatonin concentration by time of the day. Results from 87 night workers and 254 day workers followed for 24 hours since starting on the work shift.

		Total effect		Direct effect		Indirect effect	
	Samples *N*	% difference	95% CI	% difference	95% CI	% difference	95% CI
Night 20:00 – 07:59	726	−15.0	−31.4; 5.2	−9.6	−27.0; 11.9	−5.9	−10.2; −1.5
Day 08:00 – 19:59	791	−16.2	−34.6; 7.5	−18.3	−36.7; 5.4	3.0	−2.8; 9.1

[a]Adjusted for time of day, age, sex, BMI, smoking, diurnal preference and use of antidepressant medication.
[b]Light exposure is the duration of measurements above 80 lux 30 minutes prior to each saliva sample.

difference in adjusted melatonin concentrations between permanent night workers (n =19) and day workers was −27.4% (95 % CI −47.3; −0.1).

Discussion

The effect of night and day work and the mediating effect of light exposure on melatonin levels have been examined in 254 day workers and 87 night workers. As far as we are aware, we were the first to show a mediating effect of light among night shift workers. Light exposure appeared to mediate a 6% decrease in melatonin concentration during night. On days off, we observed no difference in melatonin concentration between day and night workers. On work days, night workers showed 15–16 % lower salivary melatonin concentrations compared with day workers. When night workers' work days were compared with their days off, melatonin concentrations were 15.4% lower. On days off, we observed no difference in melatonin concentration between day and night workers.

The observation of lower melatonin concentrations on work days, when comparing night workers with day workers, is in agreement with most previous field studies (Davis et al., 2012; Gómez-Acebo et al., 2015; Hansen et al., 2006; Leung et al., 2016; Mirick et al., 2013; Papantoniou et al., 2014; Schernhammer et al., 2004;) except one (Peplonska et al., 2012). This is also the case for the lower melatonin concentration observed on work days compared with days off in our analyses of night workers (Davis et al., 2012; Hansen et al., 2006; Jensen et al., 2016; Leung et al.,

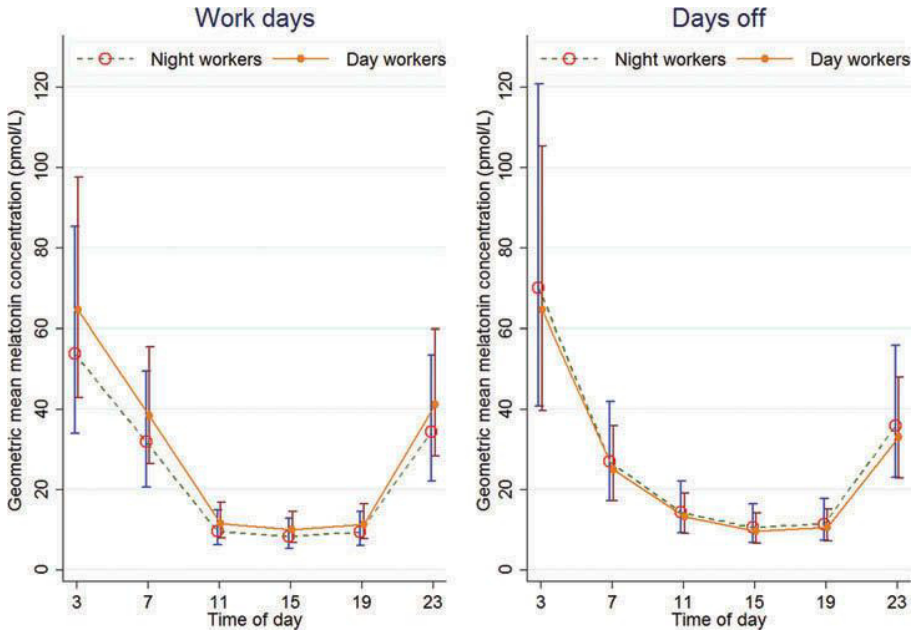

Figure 1. Estimates of geometric mean (95% CI) of salivary melatonin concentrations for day and night workers within 4-hour intervals on work days and days off. The figure shows the estimated melatonin concentrations of a worker with the following characteristics: male 40 year old, BMI=25kg/m^2, non–smoker, no antidepressant medication and morning preference.

2016; Mirick et al., 2013; Yamauchi, 2004), but conflicting results exist (Dumont et al., 2012; Gibbs et al., 2007; Grundy et al., 2011). The similar melatonin concentrations we observed for night and day workers during days off were, however, not in accordance with previous studies (Davis et al., 2012; Hansen et al., 2006; Mirick et al., 2013). This discrepancy may be because we mainly included rotating night workers and that the day off samples of the night workers were collected later after the last night shift (on average 47 hours) than in the referred studies. Our findings are on the other hand in agreement with the recent results of Jensen et al. (2016)

Our observation of lower melatonin levels with higher light exposure during night is partly in line with two previous studies, showing an inverse association between light at night and 24-hour aMT6s (Dumont et al., 2012; Papantoniou et al., 2014). However, Dumont et al. did not find an association with night time melatonin production, and Grundy et al. did not find an association between light exposure and melatonin levels in rotating shift nurses (Grundy et al., 2011).

Our observation of an mediating effect of light at night is as expected from laboratory studies (Bojkowski et al., 1987; Figueiro et al., 2006a; Rea & Figueiro, 2014; Rea et al., 2005; Revell & Skene, 2007). As far as we are aware, we are the first to show a mediating effect among workers on the night shift.

The effects of night work on melatonin concentrations during the daytime were unexplained by light exposure (the direct effect). This may be the result of adaptation to the new work schedule and the altered light, sleep, wake or meal patterns. This is supported by a laboratory study of simulated night work demonstrating melatonin suppression, despite light conditions that were designed not to induce suppression (Dumont & Paquet, 2014).

We observed lower melatonin levels in night workers than in day workers on work days, except between 01:00 and 04:59 h, the latter finding not being expected. This unexpected effect was mainly due to two night workers with melatonin concentrations above 200 pmol/L that disappeared in the adjusted analyses and was probably an accidental finding due to the low number samples in this time period.

Most of the night workers worked rotating shifts and 94 % only worked a single or two consecutive nights during the 7-day study period. Melatonin suppression has been reported to increase with the number of consecutive nights worked (Dumont & Paquet, 2014; Jensen et al., 2016; Leung et al., 2016). A recent field study showed a 5% decrease in salivary

melatonin concentration per night worked (Jensen et al., 2016). The difference in melatonin concentrations observed would therefore likely be larger if the night workers had worked more consecutive nights.

Previous studies, addressing the effect of light exposure on melatonin concentration during night work, classified participants by the mean or median light level without taking threshold or a recent time window into account (Dumont et al., 2012; Grundy et al., 2011; Papantoniou et al., 2014). This may explain why we find a more prominent effect of light than these earlier studies.

In the present study, light measurements were multiplied with a calibration factor before statistical analysis to account for variation between the light monitors (Markvart et al., 2015). Light was measured using the same procedure for all participants with the Actiwatch positioned at the upper arm, but not at eye level as suggested by Figuerio (Figueiro et al., 2013). Because of the Actiwatch positioning, there may have been a difference in perceived light at eyelevel compared to actual measured light exposure. Differences may also arise during certain light conditions due to the mismatch between the spatial and spectral sensitivity of Actiwatch toward a standard classified illuminance sensor (Figueiro et al., 2013; Price et al., 2012). This misclassification of light exposure is probably not only non-differential because light spectra may differ between night and day workers at the same time of the day. However, we expect an overall underestimation of the effects of light on melatonin concentration.

Non-visual light responses, such as circadian rhythm resetting and melatonin suppression, have a distinct spectral sensitivity compared to the visibility curve of the CIE standard observer V(λ) and appear to be most sensitive to blue light (Thapan et al., 2001). Unfortunately, however, there is no consensus of a weighted unit for the non-visual light responses (Lucas et al., 2014). Therefore, the measured light does not equal the circadian effectiveness of the light, and the estimated effect of light may be over or underestimated depending on the present light conditions.

Night work often causes phase delay (Gibbs et al., 2002; Gómez-Acebo et al., 2015; Leung et al., 2016; Papantoniou et al., 2014), and this phase shifting may induce melatonin suppression independent of light, as shown in a study of simulated night work (Dumont & Paquet, 2014). However, our data did not show an interaction between time of day and being a day worker or night worker, except in the analyses of the few permanent night workers. This finding indicates that the difference in melatonin concentration between day workers and rotating night workers was similar across the 24 h day. It also implies that a phase shift did not occur among these night workers, or the effect was masked by other effects (Jensen et al., 2016). Ninety-four % of the night workers collected saliva samples after one or two consecutive night shift, and this may be insufficient to induce a phase shift. It is, however, possible that our 4-hour sampling intervals preclude observing a minor phase shift.

Assessment of melatonin onset under dim light conditions would have made it possible to assess circadian phase because of the masking effect of ambient light. However, since our primary aim was to assess the concentrations of melatonin under real-life circumstances, no lighting conditions were imposed.

Analysis of saliva provided melatonin concentrations at specific time points. We were therefore able to estimate the association of melatonin levels with light exposure during relevant time windows (Bojkowski et al., 1987; Revell & Skene, 2007; Thapan et al., 2001). This is contrary to studies relying on urinary aMT6s measurements, which provide estimates of the cumulated melatonin production between each urine void, and where the effect of light within a shorter period may be diluted.

Salivary melatonin concentrations were analyzed with a LC-MS/MS method. The LOD of this method is lower, than what has previously been possible. Hence, the possibilities to measure melatonin concentrations during the day are better (Jensen et al., 2011). For obvious reasons, participants had to be awake to provide saliva samples. During the night, few samples were collected, especially among the day workers, confidence intervals were wider, and an effect of night work harder to demonstrate. In addition, the relative few samples at night where variation is largest made it difficult to estimate time of the acrophase, and this may add to why we did not observe a phase delay among these predominantly rotating night workers.

We adjusted for several known predictors of melatonin levels, but not for menopausal status, estrogen

medication, parity, or time since last menstrual period, that may affect melatonin concentration (Schernhammer et al., 2006). Night workers were slightly younger and probably had a higher proportion of pre-menopausal women, but this should not have confounded our results because all results were adjusted for age.

Twice as many day as night workers had morning preference. Chronotype has been suggested as an effect modifier, and night workers with morning as well as evening preference (Bhatti et al., 2014; Leung et al., 2016; Papantoniou et al., 2014) have been found to have larger melatonin suppression. Adjustment for diurnal preference did not alter the results in this study; however, the four item question was crude compared to comprehensive chronotype questionnaires.

In the mediation analyses, we conditioned on light exposure and may thus have introduced collider stratification bias if light exposure and melatonin share predictors (mediator-outcome confounders) (Richiardi et al., 2013). Age, sex, BMI, diurnal preference and depression may predict melatonin level (Bhatti et al., 2014; Burgess & Fogg, 2008; Leung et al., 2016; Papantoniou et al., 2014; Schernhammer et al., 2006), possibly also light exposure levels, and we controlled for these factors. However, little is known about individual predictors of light exposure, and residual confounding of the direct effect of night work cannot be excluded.

Conclusions

On work days, night workers showed lower salivary melatonin concentrations compared with day workers. Light exposure seemed to mediate a substantial part of the difference seen during the night, but no mediating effect of light was observed during the day time. On days off, we observed no difference in melatonin concentrations between day and night workers. These findings are in accordance with a transient and partly light-mediated effect of night work on melatonin production.

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References

Bhatti P, Mirick DK, Davis S. (2014). The impact of chronotype on melatonin levels among shift workers. Occup Environ Med. 71:195–200.

Bojkowski CJ, Aldhous ME, English J, et al. (1987). Suppression of nocturnal plasma melatonin and 6-sulphatoxymelatonin by bright and dim light in man. Horm Metab Res. 19:437–40.

Borugian MJ, Gallagher RP, Friesen MC, et al. (2005). Twenty-four-hour light exposure and melatonin levels among shift workers. J Occup Environ Med. 47:1268–75.

Burgess HJ, Fogg LF. (2008). Individual differences in the amount and timing of salivary melatonin secretion. Plos ONE. e3055.

Costa G, Haus E, Stevens R. (2010). In Scandi, Shift work and cancer: Considerations on rationale, mechanisms, and epidemiology. Scand J Work Environ Health 36:163–79.

Davis S, Mirick DK, Chen C, Stanczyk FZ. (2012). Night shift work and hormone levels in women. Cancer Epidemiol Biomarkers Prev. 21:609–18.

Dumont M, Lanctot V, Cadieux-Viau R, Paquet J. (2012). Melatonin production and light exposure of rotating night workers. Chronobiol Int. 29:203–10.

Dumont M, Paquet J. (2014). Progressive decrease of melatonin production over consecutive days of simulated night work. Chronobiol Int. 31:1231–38.

Figueiro MG, Hamner R, Bierman A, Rea MS. (2013). Comparisons of three practical field devices used to measure personal light exposures and activity levels. Light Res Technol. 45:421–34.

Figueiro MG, Rea MS, Bullough JD. (2006a). Circadian effectiveness of two polychromatic lights in suppressing human nocturnal melatonin. Neurosci Lett. 406:293–97.

Figueiro MG, Rea MS, Bullough JD. (2006b). Does architectural lighting contribute to breast cancer? J Carcinogenesis. 5:20.

Gibbs M, Hampton S, Morgan L, Arendt J. (2002). Adaptation of the circadian rhythm of 6-sulphatoxymelatonin to a shift schedule of seven nights followed by seven days in offshore oil installation workers. Neurosci Lett. 325:91–94.

Gibbs M, Hampton S, Morgan La, Arendt J. (2007). Predicting circadian response to abrupt phase shift: 6-

sulphatoxymelatonin rhythms in rotating shift workers offshore. J Biol Rhythms. 22:368–70.

Gómez-Acebo I, Dierssen-Sotos T, Papantoniou K, et al. (2015). Association between exposure to rotating night shift versus day shift using levels of 6-sulfatoxymelatonin and cortisol and other sex hormones in women. Chronobiol Int. 32:128–35.

Grubbs FE. (1950). Sample criteria for testing outlying observations. Ann Math Stat. 21:27–58.

Grundy A, Tranmer J, Richardson H, et al. (2011). The influence of light at night exposure on melatonin levels among Canadian rotating shift nurses. Cancer Epidemiol Biomarkers Prev. 20:2404–12.

Hansen ÅM, Helene Garde A, Hansen J. (2006). Diurnal urinary 6-sulfatoxymelatonin levels among healthy Danish nurses during work and leisure time. Chronobiol Int. 23:1203–15.

Hayes A. (2009). Beyond baron and Kenny: Statistical mediation analysis in the new millennium. Commun Monogr. 76:408–20.

Hebert M, Martin SK, Lee C, Eastman CI. (2002). The effects of prior light history on the suppression of melatonin by light in humans. J Pineal Res. 33:198–203.

Hill SM, Belancio VP, Dauchy RT, et al. (2015). Melatonin: An inhibitor of breast cancer. Endocr -Relat Cancer. 22: R183–R204.

Jensen MA, Hansen ÅM, Abrahamsson P, Nørgaard AW. (2011). Development and evaluation of a liquid chromatography tandem mass spectrometry method for simultaneous determination of salivary melatonin, cortisol and testosterone. J Chromatogr B Anal Technol Biomed Life Sci. 879:2527–32.

Jensen MA, Hansen ÅM, Kristiansen J, et al. (2016). Changes in the diurnal rhythms of cortisol, melatonin, and testosterone after 2, 4, and 7 consecutive night shifts in male police officers. Chronobiol Int. 11:1–13.

Kivela A. (1991). Serum melatonin during human pregnancy. Acta Endocrinol (Copenh). 124:233–37.

Kolstad HA. (2008). Nightshift work and risk of breast cancer and other cancers: A critical review of the epidemiologic evidence. Scand J Work Environ Health. 34:5–22.

Leung M, Tranmer J, Hung E, et al. (2016). Shift work, chronotype, and melatonin patterns among female hospital employees on day and night shifts. Cancer Epidemiol Biomarkers Prev. 25:830–38.

Lew GM. (1987). Morphological and biochemical changes in the pineal gland in pregnancy. Life Sci. 41:2589–96.

Lin X, Chen W, Wei F, et al. (2015). Night-shift work increases morbidity of breast cancer and all-cause mortality: A meta-analysis of 16 prospective cohort studies. Sleep Med. 16:1381–87.

Lucas RJ, Peirson SN, Berson DM, et al. (2014). Measuring and using light in the melanopsin age. Trends Neurosci. 37:1–9.

Markvart J, Hansen ÅM, Christoffersen J. (2015). Comparison and correction of the light sensor output from 48 wearable light exposure devices by using a side-by-side field calibration method. LEUKOS. J Illum Eng Soc. 11:155–71.

Mirick DK, Bhatti P, Chen C, et al. (2013). Night shift work and levels of 6-sulfatoxymelatonin and cortisol in men. Cancer Epidemiol Biomarkers Prev. 22:1079–87.

Papantoniou K, Pozo OJ, Espinosa A, et al. (2014). Circadian variation of melatonin, light exposure, and diurnal preference in day and night shift workers of both sexes. Cancer Epidemiol Biomarkers Prev. 23:1176–86.

Peplonska B, Bukowska A, Gromadzinska J, et al. (2012). Night shift work characteristics and 6-sulfatoxymelatonin (MT6s) in rotating night shift nurses and midwives. Occup Environ Med. 69:339–46.

Price LLA, Khazova M, O'Hagan JB. (2012). Performance assessment of commercial circadian personal exposure devices. Light Res Technol. 44:17–26.

Rea MS, Figueiro MG. (2014). Quantifying light-dependent circadian disruption in humans and animal models. Chronobiol Int. 31:1239–46.

Rea MS, Figueiro MG, Bullough JD, Bierman A. (2005). A model of phototransduction by the human circadian system. Brain Res Brain Res Rev. 50:213–28.

Revell VL, Skene DJ. (2007). Light-induced melatonin suppression in humans with polychromatic and monochromatic light. Chronobiol Int. 24:1125–37.

Richiardi L, Bellocco R, Zugna D. (2013). Mediation analysis in epidemiology: Methods, interpretation and bias. Int J Epidemiol. 42:1511–19.

Schernhammer ES, Kroenke CH, Dowsett M, et al. (2006). Urinary 6-sulfatoxymelatonin levels and their correlations with lifestyle factors and steroid hormone levels. J Pineal Res. 40:116–24.

Schernhammer ES, Rosner B, Willett WC, et al. (2004). Epidemiology of urinary melatonin in women and its relation to other hormones and night work. Cancer Epidemiol Biomarkers Prev. 13:936–43.

Schernhammer ES, Schulmeister K. (2004). Melatonin and cancer risk: Does light at night compromise physiologic cancer protection by lowering serum melatonin levels? Br J Cancer. 90:941–43.

Sakene DJ, Arendt J. (2006). Human circadian rhythms: Physiological and therapeutic relevance of light and melatonin. Ann Clin Biochem. 43:344–53.

Stevens RG, Brainard GC, Blask DE, et al. (2014). Breast cancer and circadian disruption from electric lighting in the modern world. CA Cancer J Clin. 64:207–18.

Stevens RG, Hansen J, Costa G, Rüdiger HW. (2011). Considerations of circadian impact for defining "shift work" in cancer studies: IARC Working Group Report. Arbeitsmed Sozialmed Umweltmed. 46:388.

Straif K, Baan R, Grosse Y, et al. (2007). Carcinogenicity of shift-work, painting, and fire-fighting. Lancet Oncol. 8:1065–66.

Thapan K, Arendt J, Skene DJ. (2001). An action spectrum for melatonin suppression: Evidence for a novel non-rod,

non-cone photoreceptor system in humans. J Physiol. 535:261–67.

Travis RC, Balkwill A, Fensom GK, et al. (2016). Night Shift Work and Breast Cancer Incidence: Three Prospective Studies and Meta-analysis of Published Studies. J Natl Cancer Inst. 108:djw169. Print 2016 Dec.

Wang F, Yeung KL, Chan WC, et al. (2013). A meta-analysis on dose-response relationship between night shift work and the risk of breast cancer. Ann Oncol. 24:2724–32.

Westgard JO, Barry PL, Hunt MR, Groth T. (1981). A multi-rule Shewhart chart for quality control in clinical chemistry. Clin Chem. 27:493–501.

Yamauchi H. (2004). Effects of night work on urinary excretion rates of 6-sulfatoxymelatonin, norepinephrine and estriol in pregnant women. Ind Health. 42:268–76.

Zeitzer JM, Dijk DJ, Kronauer R, et al. (2000). Sensitivity of the human circadian pacemaker to nocturnal light: Melatonin phase resetting and suppression. J Physiol. 526:695–702

Bilag 2. Informationsfolder

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Arbejdsmedicinsk Klinik, Aarhus Universitetshospital
Nørrebrogade 44, Bygning 2C
8000 Aarhus C
Telefon: 7846 4291
Projektmobil: 2037 3718

Det Nationale Forskningscenter for Arbejdsmiljø
Lersø Parkallé 105
2100 København Ø
Telefon: 3916 5258
Projektmobil: 2253 4699

INFORMATIONSFOLDER

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Videnskabelig undersøgelse om arbejde og lys

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Hvad betyder mængden af lys i arbejdstiden for helbredet?

Det vil forskere fra Arbejdsmedicinsk Klinik, Aarhus Universitetshospital og det Nationale Forskningscenter for Arbejdsmiljø i København undersøge i forskningsprojektet LUX@R.

Lys om dagen

Når man arbejder indenfor er mængden af lys væsentlig mindre, end når man arbejder udenfor. Vi ønsker at undersøge, om det forholdsvis lave lysniveau ved indendørsarbejde har betydning for helbredet.

Lys om natten

Når man arbejder om natten udsættes man for lys, som kan påvirke vores evne til at sove og forstyrre vores døgnrytme. I LUX@R-projektet vil vi undersøge, hvordan lys om natten hænger sammen med søvnkvalitet og forskydning af døgnrytmen.

Hvordan vil vi undersøge det?

Vi vil blandt andet foretage nogle målinger på personer som arbejder

- om natten
- indendørs om dagen
- udendørs

Som forsøgsdeltager bliver man blive bedt om at:

- Bære en lysmåler på overarmen i 7 dage. Måleren ligner et almindeligt armbåndsur og tåler al slags vejr. Lysmåleren registrerer foruden lysintensitet og lysspektret også UV-stråling og bevægelse, som bruges til at vurdere din søvn.
- Udfylde et spørgeskema om arbejde, helbred og livsstil
- Udfylde en dagbog om søvn, arbejde og livsstil, 2 gange dagligt i alle 7 dage.
- Afgive en blodprøve, som vi tager på arbejdspladsen i forbindelse med opstarten af målingerne.
- Nogle forsøgsdeltagere vil desuden blive bedt om at opsamle spytprøver over 2 dage. I spyttet måler vi markører for døgnrytme.

1100 personer er med

Undersøgelsen omfatter 1100 ansatte på forskellige arbejdspladser, hvoraf 500 er indendørs dagarbejdere, 300 er udendørsarbejdere og 300 er natarbejdere. Deltagerne er tilfældigt udvalgt blandt ansatte fra forskellige arbejdspladser med natarbejdere, indendørs dagarbejdere eller udendørsarbejdere.

Din deltagelse er vigtig

Kvaliteten af undersøgelsen afhænger af, at så mange som muligt deltager. Ved at deltage i projektet kan du bidrage til at skabe vigtig viden om, hvordan lys påvirker vores helbred. Denne viden kan bruges til at forbedre arbejdsmiljøet og forebygge helbredsproblemer.

Fortroligt

Det er frivilligt at være med, og dine oplysninger bliver behandlet fortroligt. Vi har tavshedspligt og derfor er det kun forskergruppen, som får adgang til dine oplysninger. Dog kan du altid skriftligt bede om dine egne resultater. Projektet er godkendt af Videnskabsetisk Komité (projekt-ID: M-20110214) samt Datatilsynet (projekt-ID2011-41-6850). Fortryder du at være med, kan du altid trække dig ud af undersøgelsen.

Hvad får jeg ud af at være med?

Du får din lys- og søvnprofil for hele ugen udleveret. Men kun hvis du ønsker det.

Yderligere information kontakt venligst

Helene Tilma Vistisen
Arbejdsmedicinsk Klinik,
Aarhus Universitetshospital
Nørrebrogade 44, Bygning 2C
8000 Århus C
Tlf.: 7846 4291
Projektmobil: 2037 3718
E-mail: helvis@rm.dk

Anne Helene Garde
Det Nationale Forskningscenter for Arbejdsmiljø
Lersø Parkallé 105
2100 København Ø
Tlf.: 3916 5258
Projektmobil: 2253 4699
E-mail: ahg@arbejdsmiljoforskning.dk

Bilag 3. Spørgeskema

SPØRGESKEMA

LUX@R

Videnskabelig undersøgelse om arbejde og lys

Aarhus Universitetshospital

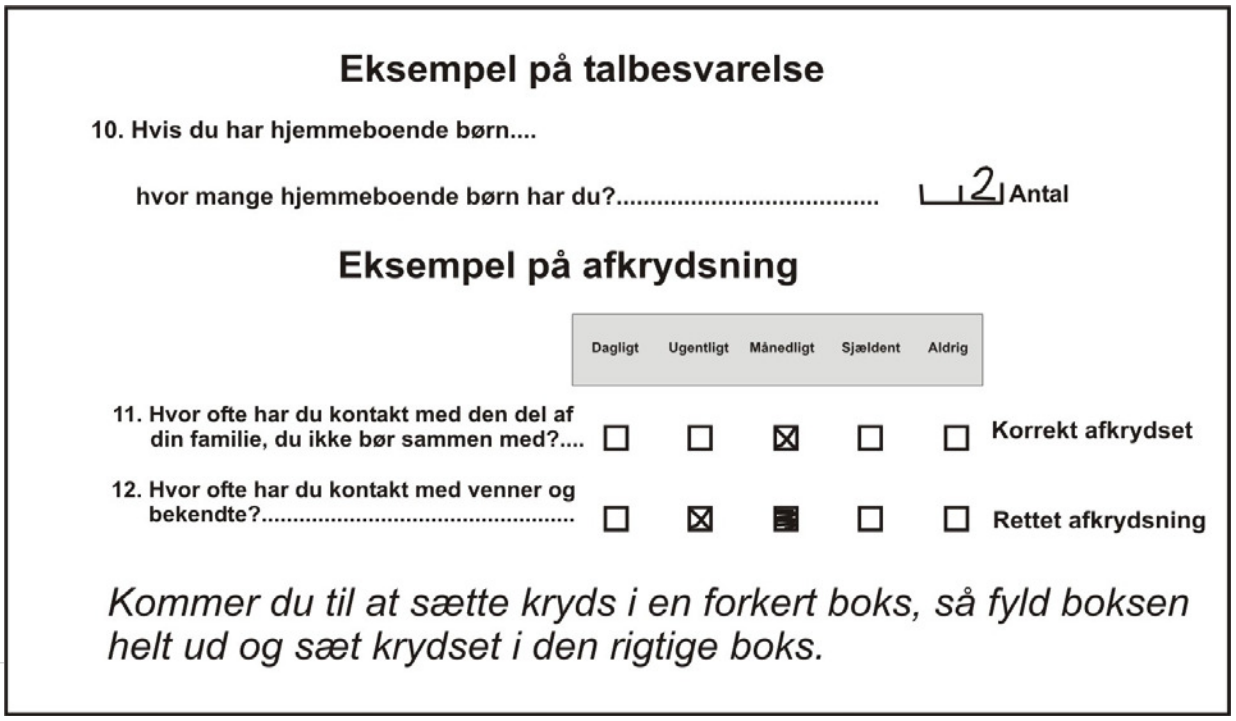
DET NATIONALE
FORSKNINGSCENTER FOR ARBEJDSMILJØ

Instruktion

Du skal ikke bruge for lang tid på spørgsmålene men give det svar, som først falder dig ind. Nogle af spørgsmålene kan minde om hinanden, men de er ikke helt ens, og de undersøger noget forskelligt.

Bemærk - ikke alle spørgsmål skal besvares!
I spørgeskemaet vil der være nogle spørgsmål, som du måske ikke behøver at svare på. Læg derfor mærke til, når du henvises til at springe nogle spørgsmål over.

Du bedes udfylde skemaet med kuglepen. Nedenfor ser du et eksempel på, hvordan forskellige sprøgsmål kan besvares.



Hvis du ønsker at spørge om noget, mens du udfylder skemaet, kontakt venligst:

Helene Tilma Vistisen
Arbejdsmedicinsk Klinik,
Aarhus Universitetshospital
Nørrebrogade 44, Bygning 2C
8000 Aarhus C
Tlf.: 7846 4291
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BAGGRUNDSOPLYSNINGER

De følgende spørgsmål handler om dine personlige baggrundsoplysninger

1. Jeg er ... ☐ Mand ☐ Kvinde

2. Hvilket år er du født? 19__

3. Hvis du er kvinde: Er du gravid? ☐ Ja ☐ Nej

ERHVERVSARBEJDE

De følgende spørgsmål handler om dit nuværende erhvervsarbejde og inkluderer også bibeskæftigelse men **ikke** frivilligt arbejde

4. Hvad er din nuværende stillingsbetegnelse ...

Skriv fx "sygeplejerske på børneafdeling" i stedet for blot "sygeplejerske" eller "montør for køkkenfirma" i stedet for blot "montør". *Skriv venligst med BLOKBOGSTAVER.*

4.A for din hovedbeskæftigelse? _____

4.B for dit bijob? _____

5. Hvilken arbejdstid har du sædvanligvis?

Sæt ét X

Fast dagarbejde (ca. mellem kl. 06 og 16)	☐
Fast aftenarbejde (ca. mellem kl. 15 og 24)	☐
Fast natarbejde (ca. mellem kl. 23 og 08)	☐
Skiftende arbejdstider som også inkluderer natarbejde	☐
Skiftende arbejdstider som ikke inkluderer natarbejde	☐

Hvis anden arbejdstid, skriv hvilken: _____

6. Hvor mange timer er du sædvanligvis indendørs om ugen i forbindelse med dit erhvervsarbejde?

Sæt ét X i hver linje

	0 timer/ uge	1-4 timer/ uge	5-9 timer/ uge	10-19 timer/ uge	20-29 timer/ uge	30-39 timer/ uge	Mere end 40 timer/ uge
Forår (mar., apr. og maj)	☐	☐	☐	☐	☐	☐	☐
Sommer (jun., jul. og aug.)	☐	☐	☐	☐	☐	☐	☐
Efterår (sep., okt. og nov.)	☐	☐	☐	☐	☐	☐	☐
Vinter (dec., jan. og feb.)	☐	☐	☐	☐	☐	☐	☐

7. Befinder du dig i bil eller andet lukket transportmiddel i forbindelse med dit erhvervsarbejde? *Sæt ét X*

Nej ☐ **Gå til spørgsmål 9**

Ja ☐ Hvilket transportmiddel _____

8. Hvor mange timer befinder du dig sædvanligvis i bil eller andet lukket transportmiddel i forbindelse med dit arbejde?

Sæt ét X i hver linje

	0 timer/ uge	1-4 timer/ uge	5-9 timer/ uge	10-19 timer/ uge	20-29 timer/ uge	30-39 timer/ uge	Mere end 40 timer/ uge
Forår (mar., apr. og maj)	☐	☐	☐	☐	☐	☐	☐
Sommer (jun., jul. og aug.)	☐	☐	☐	☐	☐	☐	☐
Efterår (sep., okt. og nov.)	☐	☐	☐	☐	☐	☐	☐
Vinter (dec., jan. og feb.)	☐	☐	☐	☐	☐	☐	☐

9. Arbejder du på noget tidspunkt udendørs i forbindelse med dit erhvervsarbejde?

Sæt ét X

Nej ☐ **Gå til spørgsmål 11**

Ja ☐

10. Hvor mange timer er du sædvanligvis udendørs om ugen i forbindelse med dit erhvervsarbejde?

Sæt ét X i hver linje

	0 timer/ uge	1-4 timer/ uge	5-9 timer/ uge	10-19 timer/ uge	20-29 timer/ uge	30-39 timer/ uge	Mere end 40 timer/ uge
Forår (mar., apr. og maj)	☐	☐	☐	☐	☐	☐	☐
Sommer (jun., jul. og aug.)	☐	☐	☐	☐	☐	☐	☐
Efterår (sep., okt. og nov.)	☐	☐	☐	☐	☐	☐	☐
Vinter (dec., jan. og feb.)	☐	☐	☐	☐	☐	☐	☐

11. Hvad er din gennemsnitlige ugentlige arbejdstid?

Skriv antal timer

Hovedbeskæftigelse ___ timer/uge

Bijob ___ timer/uge

12. Hvor fysisk anstrengende er dit arbejde sædvanligvis?

Sæt ét X

Det er mest stillesidende arbejde, som ikke kræver fysisk anstrengelse	☐
Det er mest stående eller gående arbejde, som ikke kræver fysisk anstrengelse	☐
Det er stående eller gående arbejde med en del løfte- eller bærearbejde	☐
Det er tungt eller hurtigt arbejde, som er fysisk anstrengende	☐

De følgende spørgsmål handler om det erhvervsarbejde, du har haft gennem hele dit liv, og inkluderer også bibeskæftigelse men **ikke** frivilligt arbejde

13. Hvor mange år har du sammenlagt haft erhvervsarbejde?

|__|__| år

14. Hvor lang tid har du sammenlagt arbejdet indenfor de forskellige <u>arbejdstider</u> i hele dit arbejdsliv?

Skriv ét tal i hver linje

	År	Mdr.
Fast dagarbejde (ca. mellem kl. 06 og 16)	|__|__|	|__|__|
Fast aftenarbejde (ca. mellem kl. 15 og 24)	|__|__|	|__|__|
Fast natarbejde (ca. mellem kl. 23 og 08)	|__|__|	|__|__|
Skiftende arbejdstider som også inkluderer natarbejde	|__|__|	|__|__|
Skiftende arbejdstider som ikke inkluderer natarbejde	|__|__|	|__|__|
Andet _____	|__|__|	|__|__|

15. Hvor mange år har du sammenlagt haft erhvervsarbejde, hvor du har arbejdet <u>udendørs</u> mindst 5 timer om ugen i gennemsnit?

|__|__| år

HELBRED OG LIVSSTIL

De følgende spørgsmål handler om dit helbred og din livsstil

16. Hvor høj er du, og hvor meget vejer du?

Skriv et tal i hver boks

Hvor høj er du (uden sko)? ____ cm

Hvad vejer du (uden tøj)? ____ kg

17. Tager du på nuværende tidspunkt medicin?

Sæt ét X

- ☐ Nej
- ☐ Ja, sovemedicin
- ☐ Ja, melatonin
- ☐ Ja, medicin mod depression

Hvis anden medicin, skriv hvilken: _____

_____

18. Tager du dagligt en multivitamintablet?

Sæt ét X

☐ Nej ☐ Ja

Hvis ja, hvad hedder tabletten? _____

19. Tager du dagligt tilskud af D-vitamin?

Sæt ét X

☐ Nej ☐ Ja, 1 tablet ☐ Ja, 2 tabletter ☐ Ja, 3 eller flere tabletter

Hvis ja, hvad hedder tabletten? _____

20. Tager du tilskud af levertran?

Sæt ét X

☐ Nej ☐ Ja

21. Hvor ofte spiser du i gennemsnit fisk eller skaldyr?

Sæt ét X

Aldrig	1-3 gange pr. måned	1 gang om ugen	2-3 gange om ugen	4-6 gange om ugen	Dagligt
☐	☐	☐	☐	☐	☐

22. Hvor ofte går du i solarium?

Sæt ét X

☐ Flere gange/uge ☐ Ca. 1 gang/uge ☐ Ca. 1 gang/måned ☐ Få gange om året ☐ Aldrig

23. Ryger du?

Sæt ét X

Ja ☐

Nej, men jeg har røget ☐

Nej, jeg har aldrig røget ☐

Hvis du ryger eller har røget, besvar nedenstående spørgsmål. Hvis du aldrig har røget, gå til spørgsmål 23.

I hvor mange år har du røget?

☐☐ år

24. Hvor meget ryger/røg du om dagen i gennemsnit?

Skriv et tal i hver boks

Antal cigaretter pr. dag ☐☐

Antal cerutter pr. dag ☐☐

Antal pibestop pr. dag ☐☐

25. I løbet af de sidste 4 uger hvor meget har du været genereret af ...

Sæt ét X i hver linje

	Slet ikke	Lidt	Noget	En hel del	Virkelig meget
at føle dig nedtrykt?	☐	☐	☐	☐	☐
en følelse af ingenting af være værd?	☐	☐	☐	☐	☐
tanker om at gøre en ende på dit liv?	☐	☐	☐	☐	☐
en følelse af at være fanget i en fælde?	☐	☐	☐	☐	☐
at føle dig ensom?	☐	☐	☐	☐	☐
selvbebrejdelser?	☐	☐	☐	☐	☐
at føle dig træt?	☐	☐	☐	☐	☐
at føle dig udkørt?	☐	☐	☐	☐	☐

26. Hvordan kommer du sædvanligvis til og fra arbejde?

Sæt ét X ud for hver årstid, som viser, hvordan du sædvanligvis kommer på arbejde.
Sæt ét kryds i hver linje

	Bil	Bus	Tog	Cykel	Gående	Andet
Forår (mar., apr. og maj)	☐	☐	☐	☐	☐	☐
Sommer (jun., jul. og aug.)	☐	☐	☐	☐	☐	☐
Efterår (sep., okt. og nov.)	☐	☐	☐	☐	☐	☐
Vinter (dec., jan. og feb.)	☐	☐	☐	☐	☐	☐

Hvis andet, skriv: _____

27. Hvor meget tid har du i gennemsnit brugt på hver af følgende fritidsaktiviteter i det sidste år?

Medregn også transport til og fra arbejde.
Sæt ét kryds i hver linje

	Over 4 timer/ uge	2-4 timer/ uge	Under 2 timer/ uge	Dyrker ikke denne fritidsaktivitet
Gang, cykling eller anden lettere motion, hvor du ikke bliver forpustet eller sveder	☐	☐	☐	☐
Motionsidræt, tungt havearbejde eller hurtig gang/cykling, hvor du sveder og bliver forpustet	☐	☐	☐	☐
Hård træning eller konkurrenceidræt	☐	☐	☐	☐

SØVN

Spørgsmålene i dette afsnit handler om dit søvnmønster

28. I løbet af de sidste 4 uger, hvor ofte ...

Sæt ét X ud for hvert spørgsmål

	Aldrig	Sjældent	En gang imellem	For det meste	Altid
har du haft svært ved at falde i søvn?	☐	☐	☐	☐	☐
har du haft svært ved at vågne?	☐	☐	☐	☐	☐
er du vågnet for tidligt uden at kunne falde i søvn igen?	☐	☐	☐	☐	☐
har du følt, at du ikke var udhvilet, når du vågnede?	☐	☐	☐	☐	☐
er du vågnet flere gange og har haft svært ved at falde i søvn igen?	☐	☐	☐	☐	☐
har du sovet dårligt og uroligt?	☐	☐	☐	☐	☐
har du følt dig udmattet ved opvågning?	☐	☐	☐	☐	☐

29. Hvis du skal beskrive dig selv som morgenmenneske eller aftenmenneske, hvad er du så?

Sæt ét X

Helt sikkert morgenmenneske	☐
Mere morgenmenneske end aftenmenneske	☐
Mere aftenmenneske end morgenmenneske	☐
Helt sikkert aftenmenneske	☐

30. Er du interesseret i at høre nærmere om eventuelt andre projekter omkring lysmiljøet, fx sammenhængen mellem lysmiljø og knogleskørhed?

Sæt ét X

☐ Nej ☐ Ja

HAR DU KOMMENTARER TIL SPØRGESKEMAET:

_____

_____

_____

_____

_____

_____

_____

_____

Tak fordi du tog dig tid til at udfylde spørgeskemaet!

LUX@R udføres i et samarbejde mellem Arbejdsmedicinsk Klinik ved Aarhus Universitetshospital, Det Nationale Forskningscenter for Arbejdsmiljø, Statens Byggeforskningsinstitut, VELUX A/S, Arbejds- og Miljømedicinsk Afdeling ved Bispebjerg Hospital samt Aarhus Universitetshospital, Risskov.

Arbejdsmedicinsk Klinik, Aarhus Universitetshospital
Nørrebrogade 44, Bygning 2C
8000 Aarhus C
Telefon: 7846 4291
Projektmobil: 2037 3718

Det Nationale Forskningscenter for Arbejdsmiljø
Lersø Parkallé 105
2100 København Ø
Telefon: 3916 5258
Projektmobil: 2253 4699

Bilag 4. Dagbog

DAGBOG

LUX@R

Videnskabelig undersøgelse om arbejde og lys

Aarhus Universitetshospital

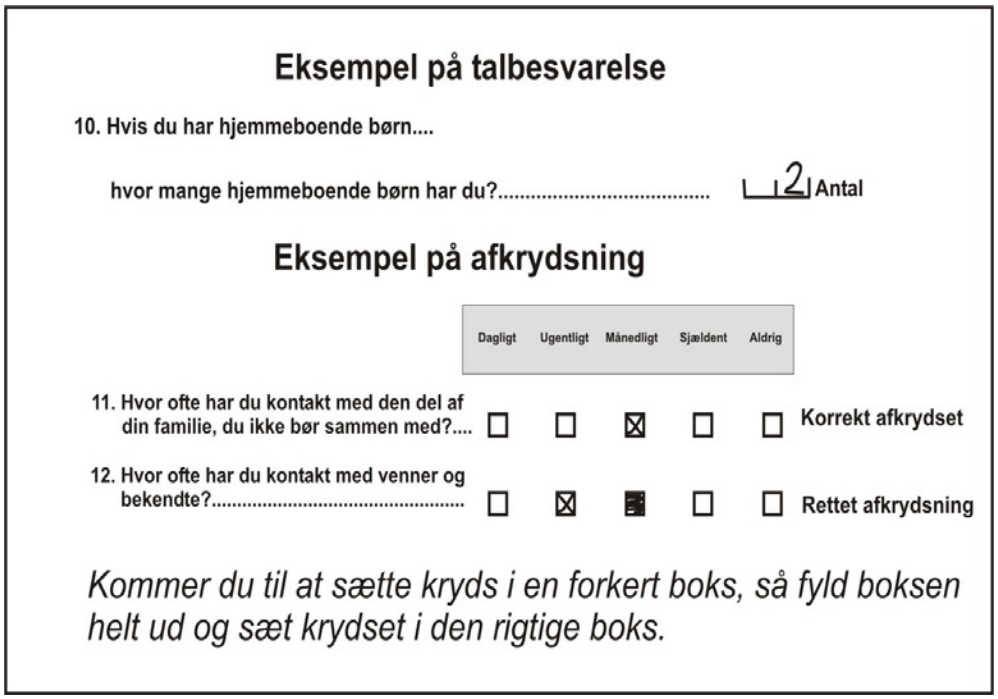
DET NATIONALE
FORSKNINGSCENTER FOR ARBEJDSMILJØ

Instruktion

Dagbogen skal udfyldes to gange dagligt: én gang efter opvågning og én gang før sengetid. Hvis du er natarbejder og sover om dagen, udfylder du dagbogen før og efter din søvn.

Du skal ikke bruge for lang tid på spørgsmålene, men give det svar, som først falder dig ind. Nogle af sprøgsmålene kan minde om hinanden, men de er ikke helt ens og de undersøger noget forskelligt.

Du bedes udfylde skemaet med kuglepen. Nedenfor ser du et eksempel på, hvordan forskellige sprøgsmål kan besvares.



Hvis du ønsker, at spørge om noget, mens du udfylder skemaet, kontakt venligst:

Helene Tilma Vistisen
Arbejdsmedicinsk Klinik,
Aarhus Universitetshospital
Nørrebrogade 44, Bygning 2C
8000 Aarhus C
Tlf.: 7846 4291
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Mobil: 2253 4699

Overblik over undersøgelsens 7 dage

Bagerst i dagbogen finde du en vejlening i brugen af lysmåleren samt en vejledning til hvordan du taget spytprøver

	1. DØGN		2. DØGN		3. DØGN		4. DØGN		5. DØGN		6. DØGN		7. DØGN		8. DØGN	
LYSMÅLER																
Dagarbejde	Dag	Nat	Dag	Nat	Dag	Nat	Dag	Nat	Dag	Nat	Dag	Nat	Dag	Nat	Dag	Nat
Natarbejde	Vågen	Sover	Vågen	Sover	Vågen	Sover	Vågen	Sover	Vågen	Sover	Vågen	Sover	Vågen	Sover	Vågen	Sover
Overarm	X		X		X		X		X		X		X		X	
Håndled*																
Natbord*																
DAGBOG																
	Når du vågner	Når du går i seng	Når du vågner	Når du går i seng	Når du vågner	Når du går i seng	Når du vågner	Når du går i seng	Når du vågner	Når du går i seng	Når du vågner	Når du går i seng	Når du vågner	Når du går i seng	Når du vågner	Når du går i seng
SPYTPRØVER		X	X	X	X	X	X	X	X	X	X	X	X	X	X	
*																

* Udfyldes i samarbejde med en projektmedarbejder

1. DØGN – Udfyldes inden du lægger dig til at sove

1. Dato: (dag, måned, år) ____ ____ 20____

2. Har du været på arbejde i dag? *Sæt også X i "Ja", hvis du inden for det seneste døgn har været på nattevagt*

- ☐ Ja
- ☐ Nej, jeg har haft fri
- ☐ Nej, jeg har holdt egen sygedag
- ☐ Nej, jeg har holdt barnets sygedag

} **Gå til spørgsmål 6**

3. Hvornår startede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ____ : ____ Dato (dag, måned) ____ - ____

4. Hvornår sluttede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ____ : ____ Dato (dag, måned) ____ - ____

5. Har du været på nattevagt i nat? *Sæt kun ét X*

☐ Ja ☐ Nej **Hvis ja**, besvar nedenstående spørgsmål. **Hvis nej**, gå til spørgsmål 6.

Hvor lang tid sov du sammenlagt i løbet af nattevagten? Antal minutter ____

6. Har du drukket følgende indenfor de seneste 6 timer?

Sæt gerne flere X'er ☐ Ja, kaffe ☐ Ja, te ☐ Ja, cola ☐ Nej, ingen af delene

7. Har du benyttet lysterapilampe i dag?

Sæt kun ét X ☐ Ja ☐ Nej

8. Indenfor det seneste døgn, hvornår har du da i minimum 20 minutter:

Sæt gerne flere X i én linje, hvis du fx både har været udendørs og indendørs indenfor samme time

	Ikke haft lysmåler på	Været udendørs	Været indendørs	Anstrengt dig så meget fysisk, at du svedte og blev forpustet: På arbejde	I din fritid
Kl. 00 - 01	☐	☐	☐	☐	☐
Kl. 01 - 02	☐	☐	☐	☐	☐
Kl. 02 - 03	☐	☐	☐	☐	☐
Kl. 03 - 04	☐	☐	☐	☐	☐
Kl. 04 - 05	☐	☐	☐	☐	☐
Kl. 05 - 06	☐	☐	☐	☐	☐
Kl. 06 - 07	☐	☐	☐	☐	☐
Kl. 07 - 08	☐	☐	☐	☐	☐
Kl. 08 - 09	☐	☐	☐	☐	☐
Kl. 09 - 10	☐	☐	☐	☐	☐
Kl. 10 - 11	☐	☐	☐	☐	☐
Kl. 11 - 12	☐	☐	☐	☐	☐
Kl. 12 - 13	☐	☐	☐	☐	☐
Kl. 13 - 14	☐	☐	☐	☐	☐
Kl. 14 - 15	☐	☐	☐	☐	☐
Kl. 15 - 16	☐	☐	☐	☐	☐
Kl. 16 - 17	☐	☐	☐	☐	☐
Kl. 17 - 18	☐	☐	☐	☐	☐
Kl. 18 - 19	☐	☐	☐	☐	☐
Kl. 19 - 20	☐	☐	☐	☐	☐
Kl. 20 - 21	☐	☐	☐	☐	☐
Kl. 21 - 22	☐	☐	☐	☐	☐
Kl. 22 - 23	☐	☐	☐	☐	☐
Kl. 23 - 24	☐	☐	☐	☐	☐

2. DØGN - Udfyldes når du vågner

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Hvor har lysmåleren været placeret, mens du sov? *Sæt ét X*

☐ På håndleddet ☐ Ved siden af sengen

3. Hvornår lagde du dig til at sove?

Skriv det klokkeslæt, hvor du lagde dig til at sove. Bemærk, at nogle personer går i seng før de ønsker at sove, fx. fordi de læser

Klokken ☐☐ : ☐☐

4. Hvor længe var du om at falde i søvn? *Skriv ét tal*

Minutter ☐☐☐

5. Hvornår vågnede du? *Skriv det klokkeslæt, hvor du vågnede*

Klokken ☐☐ : ☐☐

6. Var det svært at falde i søvn? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

7. Sov du uroligt? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

8. Vågnede du for tidligt uden at kunne sove videre? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

9. Hvor mange gange vågnede du i løbet af natten? *Sæt kun ét X*

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 eller flere

10. Var det let at stå op? *Sæt kun ét X*

☐ Meget let ☐ Let ☐ Hverken let eller svært ☐ Svært ☐ Meget svært

11. Hvor udhvilet er du? *Sæt kun ét X*

☐ Helt ☐ Meget ☐ Ganske ☐ Lidt ☐ Slet ikke

12. Indtog du følgende umiddelbart inden du faldt i søvn? *Sæt kun ét X*

☐ Ja, sovemiddel ☐ Ja, alkohol ☐ Ja, smertestillende ☐ Nej, ingen af delene

13. Har du i løbet af natten/søvnen haft lyset tændt i samme rum som dig?
Sæt kun ét X

☐ Nej ☐ Ja

2. DØGN - Udfyldes inden du lægger dig til at sove

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Har du været på arbejde i dag? *Sæt også X i "Ja", hvis du inden for det seneste døgn har været på nattevagt*

- ☐ Ja
- ☐ Nej, jeg har haft fri
- ☐ Nej, jeg har holdt egen sygedag
- ☐ Nej, jeg har holdt barnets sygedag

} **Gå til spørgsmål 6**

3. Hvornår startede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

4. Hvornår sluttede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

5. Har du været på nattevagt i nat? *Sæt kun ét X*

☐ Ja ☐ Nej **Hvis ja**, besvar nedenstående spørgsmål. **Hvis nej**, gå til spørgsmål 6.

Hvor lang tid sov du sammenlagt i løbet af nattevagten? Antal minutter ☐☐☐

6. Har du drukket følgende indenfor de seneste 6 timer?

Sæt gerne flere X'er ☐ Ja, kaffe ☐ Ja, te ☐ Ja, cola ☐ Nej, ingen af delene

7. Har du benyttet lysterapilampe i dag?

Sæt kun ét X ☐ Ja ☐ Nej

8. Indenfor det seneste døgn, hvornår har du da i minimum 20 minutter:

Sæt gerne flere X i én linje, hvis du fx både har været udendørs og indendørs indenfor samme time

	Ikke haft lysmåler på	Været udendørs	Været indendørs	Anstrengt dig så meget fysisk, at du svedte og blev forpustet: På arbejde	I din fritid
Kl. 00 - 01	☐	☐	☐	☐	☐
Kl. 01 - 02	☐	☐	☐	☐	☐
Kl. 02 - 03	☐	☐	☐	☐	☐
Kl. 03 - 04	☐	☐	☐	☐	☐
Kl. 04 - 05	☐	☐	☐	☐	☐
Kl. 05 - 06	☐	☐	☐	☐	☐
Kl. 06 - 07	☐	☐	☐	☐	☐
Kl. 07 - 08	☐	☐	☐	☐	☐
Kl. 08 - 09	☐	☐	☐	☐	☐
Kl. 09 - 10	☐	☐	☐	☐	☐
Kl. 10 - 11	☐	☐	☐	☐	☐
Kl. 11 - 12	☐	☐	☐	☐	☐
Kl. 12 - 13	☐	☐	☐	☐	☐
Kl. 13 - 14	☐	☐	☐	☐	☐
Kl. 14 - 15	☐	☐	☐	☐	☐
Kl. 15 - 16	☐	☐	☐	☐	☐
Kl. 16 - 17	☐	☐	☐	☐	☐
Kl. 17 - 18	☐	☐	☐	☐	☐
Kl. 18 - 19	☐	☐	☐	☐	☐
Kl. 19 - 20	☐	☐	☐	☐	☐
Kl. 20 - 21	☐	☐	☐	☐	☐
Kl. 21 - 22	☐	☐	☐	☐	☐
Kl. 22 - 23	☐	☐	☐	☐	☐
Kl. 23 - 24	☐	☐	☐	☐	☐

3. DØGN - Udfyldes når du vågner

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Hvor har lysmåleren været placeret, mens du sov? *Sæt ét X*

☐ På håndleddet ☐ Ved siden af sengen

3. Hvornår lagde du dig til at sove?

Skriv det klokkeslæt, hvor du lagde dig til at sove. Bemærk, at nogle personer går i seng før de ønsker at sove, fx. fordi de læser

Klokken ☐☐ : ☐☐

4. Hvor længe var du om at falde i søvn? *Skriv ét tal*

Minutter ☐☐☐

5. Hvornår vågnede du? *Skriv det klokkeslæt, hvor du vågnede*

Klokken ☐☐ : ☐☐

6. Var det <u>svært at falde i søvn</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

7. Sov du <u>uroligt</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

8. Vågnede du <u>for tidligt</u> uden at kunne sove videre? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

9. Hvor mange gange vågnede du i løbet af natten? *Sæt kun ét X*

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 eller flere

10. Var det <u>let at stå op</u>? *Sæt kun ét X*

☐ Meget let ☐ Let ☐ Hverken let eller svært ☐ Svært ☐ Meget svært

11. Hvor <u>udhvilet</u> er du? *Sæt kun ét X*

☐ Helt ☐ Meget ☐ Ganske ☐ Lidt ☐ Slet ikke

12. Indtog du følgende umiddelbart inden du faldt i søvn? *Sæt kun ét X*

☐ Ja, sovemiddel ☐ Ja, alkohol ☐ Ja, smertestillende ☐ Nej, ingen af delene

13. Har du i løbet af natten/søvnen haft lyset tændt i samme rum som dig?
Sæt kun ét X

☐ Nej ☐ Ja

3. DØGN - Udfyldes inden du lægger dig til at sove

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Har du været på arbejde i dag? *Sæt også X i "Ja", hvis du inden for det seneste døgn har været på nattevagt*

- ☐ Ja
- ☐ Nej, jeg har haft fri
- ☐ Nej, jeg har holdt egen sygedag
- ☐ Nej, jeg har holdt barnets sygedag

} **Gå til spørgsmål 6**

3. Hvornår startede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

4. Hvornår sluttede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

5. Har du været på nattevagt i nat? *Sæt kun ét X*

☐ Ja ☐ Nej **Hvis ja**, besvar nedenstående spørgsmål. **Hvis nej**, gå til spørgsmål 6.

Hvor lang tid sov du sammenlagt i løbet af nattevagten? Antal minutter ☐☐☐

6. Har du drukket følgende indenfor de seneste 6 timer?

Sæt gerne flere X'er ☐ Ja, kaffe ☐ Ja, te ☐ Ja, cola ☐ Nej, ingen af delene

7. Har du benyttet lysterapilampe i dag?

Sæt kun ét X ☐ Ja ☐ Nej

8. Indenfor det seneste døgn, hvornår har du da i minimum 20 minutter:

Sæt gerne flere X i én linje, hvis du fx både har været udendørs og indendørs indenfor samme time

	Ikke haft lysmåler på	Været udendørs	Været indendørs	Anstrengt dig så meget fysisk, at du svedte og blev forpustet: På arbejde	I din fritid
Kl. 00 - 01	☐	☐	☐	☐	☐
Kl. 01 - 02	☐	☐	☐	☐	☐
Kl. 02 - 03	☐	☐	☐	☐	☐
Kl. 03 - 04	☐	☐	☐	☐	☐
Kl. 04 - 05	☐	☐	☐	☐	☐
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Kl. 06 - 07	☐	☐	☐	☐	☐
Kl. 07 - 08	☐	☐	☐	☐	☐
Kl. 08 - 09	☐	☐	☐	☐	☐
Kl. 09 - 10	☐	☐	☐	☐	☐
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Kl. 11 - 12	☐	☐	☐	☐	☐
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Kl. 13 - 14	☐	☐	☐	☐	☐
Kl. 14 - 15	☐	☐	☐	☐	☐
Kl. 15 - 16	☐	☐	☐	☐	☐
Kl. 16 - 17	☐	☐	☐	☐	☐
Kl. 17 - 18	☐	☐	☐	☐	☐
Kl. 18 - 19	☐	☐	☐	☐	☐
Kl. 19 - 20	☐	☐	☐	☐	☐
Kl. 20 - 21	☐	☐	☐	☐	☐
Kl. 21 - 22	☐	☐	☐	☐	☐
Kl. 22 - 23	☐	☐	☐	☐	☐
Kl. 23 - 24	☐	☐	☐	☐	☐

4. DØGN - Udfyldes når du vågner

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Hvor har lysmåleren været placeret, mens du sov? *Sæt ét X*

☐ På håndleddet ☐ Ved siden af sengen

3. Hvornår lagde du dig til at sove?

Skriv det klokkeslæt, hvor du lagde dig til at sove. Bemærk, at nogle personer går i seng før de ønsker at sove, fx. fordi de læser

Klokken ☐☐ : ☐☐

4. Hvor længe var du om at falde i søvn? *Skriv ét tal*

Minutter ☐☐☐

5. Hvornår vågnede du? *Skriv det klokkeslæt, hvor du vågnede*

Klokken ☐☐ : ☐☐

6. Var det <u>svært at falde i søvn</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

7. Sov du <u>uroligt</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

8. Vågnede du <u>for tidligt</u> uden at kunne sove videre? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

9. Hvor mange gange vågnede du i løbet af natten? *Sæt kun ét X*

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 eller flere

10. Var det <u>let at stå op</u>? *Sæt kun ét X*

☐ Meget let ☐ Let ☐ Hverken let eller svært ☐ Svært ☐ Meget svært

11. Hvor <u>udhvilet</u> er du? *Sæt kun ét X*

☐ Helt ☐ Meget ☐ Ganske ☐ Lidt ☐ Slet ikke

12. Indtog du følgende umiddelbart inden du faldt i søvn? *Sæt kun ét X*

☐ Ja, sovemiddel ☐ Ja, alkohol ☐ Ja, smertestillende ☐ Nej, ingen af delene

13. Har du i løbet af natten/søvnen haft lyset tændt i samme rum som dig?
Sæt kun ét X

☐ Nej ☐ Ja

4. DØGN - Udfyldes inden du lægger dig til at sove

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Har du været på arbejde i dag? *Sæt også X i "Ja", hvis du inden for det seneste døgn har været på nattevagt*

- ☐ Ja
- ☐ Nej, jeg har haft fri
- ☐ Nej, jeg har holdt egen sygedag
- ☐ Nej, jeg har holdt barnets sygedag

} **Gå til spørgsmål 6**

3. Hvornår startede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

4. Hvornår sluttede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

5. Har du været på nattevagt i nat? *Sæt kun ét X*

☐ Ja ☐ Nej **Hvis ja**, besvar nedenstående spørgsmål. **Hvis nej**, gå til spørgsmål 6.

Hvor lang tid sov du sammenlagt i løbet af nattevagten? Antal minutter ☐☐☐

6. Har du drukket følgende indenfor de seneste 6 timer?

Sæt gerne flere X'er ☐ Ja, kaffe ☐ Ja, te ☐ Ja, cola ☐ Nej, ingen af delene

7. Har du benyttet lysterapilampe i dag?

Sæt kun ét X ☐ Ja ☐ Nej

8. Indenfor det seneste døgn, hvornår har du da i minimum 20 minutter:

Sæt gerne flere X i én linje, hvis du fx både har været udendørs og indendørs indenfor samme time

	Ikke haft lysmåler på	Været udendørs	Været indendørs	Anstrengt dig så meget fysisk, at du svedte og blev forpustet: På arbejde	I din fritid
Kl. 00 - 01	☐	☐	☐	☐	☐
Kl. 01 - 02	☐	☐	☐	☐	☐
Kl. 02 - 03	☐	☐	☐	☐	☐
Kl. 03 - 04	☐	☐	☐	☐	☐
Kl. 04 - 05	☐	☐	☐	☐	☐
Kl. 05 - 06	☐	☐	☐	☐	☐
Kl. 06 - 07	☐	☐	☐	☐	☐
Kl. 07 - 08	☐	☐	☐	☐	☐
Kl. 08 - 09	☐	☐	☐	☐	☐
Kl. 09 - 10	☐	☐	☐	☐	☐
Kl. 10 - 11	☐	☐	☐	☐	☐
Kl. 11 - 12	☐	☐	☐	☐	☐
Kl. 12 - 13	☐	☐	☐	☐	☐
Kl. 13 - 14	☐	☐	☐	☐	☐
Kl. 14 - 15	☐	☐	☐	☐	☐
Kl. 15 - 16	☐	☐	☐	☐	☐
Kl. 16 - 17	☐	☐	☐	☐	☐
Kl. 17 - 18	☐	☐	☐	☐	☐
Kl. 18 - 19	☐	☐	☐	☐	☐
Kl. 19 - 20	☐	☐	☐	☐	☐
Kl. 20 - 21	☐	☐	☐	☐	☐
Kl. 21 - 22	☐	☐	☐	☐	☐
Kl. 22 - 23	☐	☐	☐	☐	☐
Kl. 23 - 24	☐	☐	☐	☐	☐

5. DØGN - Udfyldes når du vågner

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Hvor har lysmåleren været placeret, mens du sov? *Sæt ét X*

☐ På håndleddet ☐ Ved siden af sengen

3. Hvornår lagde du dig til at sove?

Skriv det klokkeslæt, hvor du lagde dig til at sove. Bemærk, at nogle personer går i seng før de ønsker at sove, fx. fordi de læser

Klokken ☐☐ : ☐☐

4. Hvor længe var du om at falde i søvn? *Skriv ét tal*

Minutter ☐☐☐

5. Hvornår vågnede du? *Skriv det klokkeslæt, hvor du vågnede*

Klokken ☐☐ : ☐☐

6. Var det <u>svært at falde i søvn</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

7. Sov du <u>uroligt</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

8. Vågnede du <u>for tidligt</u> uden at kunne sove videre? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

9. Hvor mange gange vågnede du i løbet af natten? *Sæt kun ét X*

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 eller flere

10. Var det <u>let at stå op</u>? *Sæt kun ét X*

☐ Meget let ☐ Let ☐ Hverken let eller svært ☐ Svært ☐ Meget svært

11. Hvor <u>udhvilet</u> er du? *Sæt kun ét X*

☐ Helt ☐ Meget ☐ Ganske ☐ Lidt ☐ Slet ikke

12. Indtog du følgende umiddelbart inden du faldt i søvn? *Sæt kun ét X*

☐ Ja, sovemiddel ☐ Ja, alkohol ☐ Ja, smertestillende ☐ Nej, ingen af delene

13. Har du i løbet af natten/søvnen haft lyset tændt i samme rum som dig?
Sæt kun ét X

☐ Nej ☐ Ja

5. DØGN - Udfyldes inden du lægger dig til at sove

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Har du været på arbejde i dag? *Sæt også X i "Ja", hvis du inden for det seneste døgn har været på nattevagt*

- ☐ Ja
- ☐ Nej, jeg har haft fri
- ☐ Nej, jeg har holdt egen sygedag
- ☐ Nej, jeg har holdt barnets sygedag

} **Gå til spørgsmål 6**

3. Hvornår startede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

4. Hvornår sluttede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

5. Har du været på nattevagt i nat? *Sæt kun ét X*

☐ Ja ☐ Nej **Hvis ja**, besvar nedenstående spørgsmål. **Hvis nej**, gå til spørgsmål 6.

Hvor lang tid sov du sammenlagt i løbet af nattevagten? Antal minutter ☐☐☐

6. Har du drukket følgende indenfor de seneste 6 timer?

Sæt gerne flere X'er ☐ Ja, kaffe ☐ Ja, te ☐ Ja, cola ☐ Nej, ingen af delene

7. Har du benyttet lysterapilampe i dag?

Sæt kun ét X ☐ Ja ☐ Nej

8. Indenfor det seneste døgn, hvornår har du da i minimum 20 minutter:

Sæt gerne flere X i én linje, hvis du fx både har været udendørs og indendørs indenfor samme time

	Ikke haft lysmåler på	Været udendørs	Været indendørs	Anstrengt dig så meget fysisk, at du svedte og blev forpustet: På arbejde	I din fritid
Kl. 00 - 01	☐	☐	☐	☐	☐
Kl. 01 - 02	☐	☐	☐	☐	☐
Kl. 02 - 03	☐	☐	☐	☐	☐
Kl. 03 - 04	☐	☐	☐	☐	☐
Kl. 04 - 05	☐	☐	☐	☐	☐
Kl. 05 - 06	☐	☐	☐	☐	☐
Kl. 06 - 07	☐	☐	☐	☐	☐
Kl. 07 - 08	☐	☐	☐	☐	☐
Kl. 08 - 09	☐	☐	☐	☐	☐
Kl. 09 - 10	☐	☐	☐	☐	☐
Kl. 10 - 11	☐	☐	☐	☐	☐
Kl. 11 - 12	☐	☐	☐	☐	☐
Kl. 12 - 13	☐	☐	☐	☐	☐
Kl. 13 - 14	☐	☐	☐	☐	☐
Kl. 14 - 15	☐	☐	☐	☐	☐
Kl. 15 - 16	☐	☐	☐	☐	☐
Kl. 16 - 17	☐	☐	☐	☐	☐
Kl. 17 - 18	☐	☐	☐	☐	☐
Kl. 18 - 19	☐	☐	☐	☐	☐
Kl. 19 - 20	☐	☐	☐	☐	☐
Kl. 20 - 21	☐	☐	☐	☐	☐
Kl. 21 - 22	☐	☐	☐	☐	☐
Kl. 22 - 23	☐	☐	☐	☐	☐
Kl. 23 - 24	☐	☐	☐	☐	☐

6. DØGN - Udfyldes når du vågner

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Hvor har lysmåleren været placeret, mens du sov? *Sæt ét X*

☐ På håndleddet ☐ Ved siden af sengen

3. Hvornår lagde du dig til at sove?

Skriv det klokkeslæt, hvor du lagde dig til at sove. Bemærk, at nogle personer går i seng før de ønsker at sove, fx. fordi de læser

Klokken ☐☐ : ☐☐

4. Hvor længe var du om at falde i søvn? *Skriv ét tal*

Minutter ☐☐☐

5. Hvornår vågnede du? *Skriv det klokkeslæt, hvor du vågnede*

Klokken ☐☐ : ☐☐

6. Var det <u>svært at falde i søvn</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

7. Sov du <u>uroligt</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

8. Vågnede du <u>for tidligt</u> uden at kunne sove videre? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

9. Hvor mange gange vågnede du i løbet af natten? *Sæt kun ét X*

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 eller flere

10. Var det <u>let at stå op</u>? *Sæt kun ét X*

☐ Meget let ☐ Let ☐ Hverken let eller svært ☐ Svært ☐ Meget svært

11. Hvor <u>udhvilet</u> er du? *Sæt kun ét X*

☐ Helt ☐ Meget ☐ Ganske ☐ Lidt ☐ Slet ikke

12. Indtog du følgende umiddelbart inden du faldt i søvn? *Sæt kun ét X*

☐ Ja, sovemiddel ☐ Ja, alkohol ☐ Ja, smertestillende ☐ Nej, ingen af delene

13. Har du i løbet af natten/søvnen haft lyset tændt i samme rum som dig?
Sæt kun ét X

☐ Nej ☐ Ja

6. DØGN - Udfyldes inden du lægger dig til at sove

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Har du været på arbejde i dag? *Sæt også X i "Ja", hvis du inden for det seneste døgn har været på nattevagt*

- ☐ Ja
- ☐ Nej, jeg har haft fri
- ☐ Nej, jeg har holdt egen sygedag
- ☐ Nej, jeg har holdt barnets sygedag

} **Gå til spørgsmål 6**

3. Hvornår startede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

4. Hvornår sluttede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ☐☐ : ☐☐ Dato (dag, måned) ☐☐ - ☐☐

5. Har du været på nattevagt i nat? *Sæt kun ét X*

☐ Ja ☐ Nej **Hvis ja**, besvar nedenstående spørgsmål. **Hvis nej**, gå til spørgsmål 6.

Hvor lang tid sov du sammenlagt i løbet af nattevagten? Antal minutter ☐☐☐

6. Har du drukket følgende indenfor de seneste 6 timer?

Sæt gerne flere X'er ☐ Ja, kaffe ☐ Ja, te ☐ Ja, cola ☐ Nej, ingen af delene

7. Har du benyttet lysterapilampe i dag?

Sæt kun ét X ☐ Ja ☐ Nej

8. Indenfor det seneste døgn, hvornår har du da i minimum 20 minutter:

Sæt gerne flere X i én linje, hvis du fx både har været udendørs og indendørs indenfor samme time

	Ikke haft lysmåler på	Været udendørs	Været indendørs	Anstrengt dig så meget fysisk, at du svedte og blev forpustet: På arbejde	I din fritid
Kl. 00 - 01	☐	☐	☐	☐	☐
Kl. 01 - 02	☐	☐	☐	☐	☐
Kl. 02 - 03	☐	☐	☐	☐	☐
Kl. 03 - 04	☐	☐	☐	☐	☐
Kl. 04 - 05	☐	☐	☐	☐	☐
Kl. 05 - 06	☐	☐	☐	☐	☐
Kl. 06 - 07	☐	☐	☐	☐	☐
Kl. 07 - 08	☐	☐	☐	☐	☐
Kl. 08 - 09	☐	☐	☐	☐	☐
Kl. 09 - 10	☐	☐	☐	☐	☐
Kl. 10 - 11	☐	☐	☐	☐	☐
Kl. 11 - 12	☐	☐	☐	☐	☐
Kl. 12 - 13	☐	☐	☐	☐	☐
Kl. 13 - 14	☐	☐	☐	☐	☐
Kl. 14 - 15	☐	☐	☐	☐	☐
Kl. 15 - 16	☐	☐	☐	☐	☐
Kl. 16 - 17	☐	☐	☐	☐	☐
Kl. 17 - 18	☐	☐	☐	☐	☐
Kl. 18 - 19	☐	☐	☐	☐	☐
Kl. 19 - 20	☐	☐	☐	☐	☐
Kl. 20 - 21	☐	☐	☐	☐	☐
Kl. 21 - 22	☐	☐	☐	☐	☐
Kl. 22 - 23	☐	☐	☐	☐	☐
Kl. 23 - 24	☐	☐	☐	☐	☐

7. DØGN - Udfyldes når du vågner

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Hvor har lysmåleren været placeret, mens du sov? *Sæt ét X*

☐ På håndleddet ☐ Ved siden af sengen

3. Hvornår lagde du dig til at sove?

Skriv det klokkeslæt, hvor du lagde dig til at sove. Bemærk, at nogle personer går i seng før de ønsker at sove, fx. fordi de læser

Klokken ☐☐ : ☐☐

4. Hvor længe var du om at falde i søvn? *Skriv ét tal*

Minutter ☐☐☐

5. Hvornår vågnede du? *Skriv det klokkeslæt, hvor du vågnede*

Klokken ☐☐ : ☐☐

6. Var det <u>svært at falde i søvn</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

7. Sov du <u>uroligt</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

8. Vågnede du <u>for tidligt</u> uden at kunne sove videre? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

9. Hvor mange gange vågnede du i løbet af natten? *Sæt kun ét X*

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 eller flere

10. Var det <u>let at stå op</u>? *Sæt kun ét X*

☐ Meget let ☐ Let ☐ Hverken let eller svært ☐ Svært ☐ Meget svært

11. Hvor <u>udhvilet</u> er du? *Sæt kun ét X*

☐ Helt ☐ Meget ☐ Ganske ☐ Lidt ☐ Slet ikke

12. Indtog du følgende umiddelbart inden du faldt i søvn? *Sæt kun ét X*

☐ Ja, sovemiddel ☐ Ja, alkohol ☐ Ja, smertestillende ☐ Nej, ingen af delene

13. Har du i løbet af natten/søvnen haft lyset tændt i samme rum som dig?
Sæt kun ét X

☐ Nej ☐ Ja

7. DØGN - Udfyldes inden du lægger dig til at sove

1. Dato: (dag, måned, år) ____ ____ 20____

2. Har du været på arbejde i dag? *Sæt også X i "Ja", hvis du inden for det seneste døgn har været på nattevagt*

- ☐ Ja
- ☐ Nej, jeg har haft fri
- ☐ Nej, jeg har holdt egen sygedag
- ☐ Nej, jeg har holdt barnets sygedag

} **Gå til spørgsmål 6**

3. Hvornår startede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ____ : ____ Dato (dag, måned) ____ - ____

4. Hvornår sluttede din arbejdsdag? *Skriv et tal i hver boks*

Klokken ____ : ____ Dato (dag, måned) ____ - ____

5. Har du været på nattevagt i nat? *Sæt kun ét X*

☐ Ja ☐ Nej **Hvis ja**, besvar nedenstående spørgsmål. **Hvis nej**, gå til spørgsmål 6.

Hvor lang tid sov du sammenlagt i løbet af nattevagten? Antal minutter ____

6. Har du drukket følgende indenfor de seneste 6 timer?

Sæt gerne flere X'er ☐ Ja, kaffe ☐ Ja, te ☐ Ja, cola ☐ Nej, ingen af delene

7. Har du benyttet lysterapilampe i dag?

Sæt kun ét X ☐ Ja ☐ Nej

8. Indenfor det seneste døgn, hvornår har du da i minimum 20 minutter:

Sæt gerne flere X i én linje, hvis du fx både har været udendørs og indendørs indenfor samme time

	Ikke haft lysmåler på	Været udendørs	Været indendørs	Anstrengt dig så meget fysisk, at du svedte og blev forpustet: På arbejde	I din fritid
Kl. 00 - 01	☐	☐	☐	☐	☐
Kl. 01 - 02	☐	☐	☐	☐	☐
Kl. 02 - 03	☐	☐	☐	☐	☐
Kl. 03 - 04	☐	☐	☐	☐	☐
Kl. 04 - 05	☐	☐	☐	☐	☐
Kl. 05 - 06	☐	☐	☐	☐	☐
Kl. 06 - 07	☐	☐	☐	☐	☐
Kl. 07 - 08	☐	☐	☐	☐	☐
Kl. 08 - 09	☐	☐	☐	☐	☐
Kl. 09 - 10	☐	☐	☐	☐	☐
Kl. 10 - 11	☐	☐	☐	☐	☐
Kl. 11 - 12	☐	☐	☐	☐	☐
Kl. 12 - 13	☐	☐	☐	☐	☐
Kl. 13 - 14	☐	☐	☐	☐	☐
Kl. 14 - 15	☐	☐	☐	☐	☐
Kl. 15 - 16	☐	☐	☐	☐	☐
Kl. 16 - 17	☐	☐	☐	☐	☐
Kl. 17 - 18	☐	☐	☐	☐	☐
Kl. 18 - 19	☐	☐	☐	☐	☐
Kl. 19 - 20	☐	☐	☐	☐	☐
Kl. 20 - 21	☐	☐	☐	☐	☐
Kl. 21 - 22	☐	☐	☐	☐	☐
Kl. 22 - 23	☐	☐	☐	☐	☐
Kl. 23 - 24	☐	☐	☐	☐	☐

8. DØGN - Udfyldes når du vågner

1. Dato: (dag, måned, år) ☐☐ ☐☐ 20☐☐

2. Hvor har lysmåleren været placeret, mens du sov? *Sæt ét X*

☐ På håndleddet ☐ Ved siden af sengen

3. Hvornår lagde du dig til at sove?

Skriv det klokkeslæt, hvor du lagde dig til at sove. Bemærk, at nogle personer går i seng før de ønsker at sove, fx. fordi de læser

Klokken ☐☐ : ☐☐

4. Hvor længe var du om at falde i søvn? *Skriv ét tal*

Minutter ☐☐☐

5. Hvornår vågnede du? *Skriv det klokkeslæt, hvor du vågnede*

Klokken ☐☐ : ☐☐

6. Var det <u>svært at falde i søvn</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

7. Sov du <u>uroligt</u>? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

8. Vågnede du <u>for tidligt</u> uden at kunne sove videre? *Sæt kun ét X*

☐ Slet ikke ☐ Meget lidt ☐ Noget ☐ Ganske meget ☐ Meget

9. Hvor mange gange vågnede du i løbet af natten? *Sæt kun ét X*

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 eller flere

10. Var det <u>let at stå op</u>? *Sæt kun ét X*

☐ Meget let ☐ Let ☐ Hverken let eller svært ☐ Svært ☐ Meget svært

11. Hvor <u>udhvilet</u> er du? *Sæt kun ét X*

☐ Helt ☐ Meget ☐ Ganske ☐ Lidt ☐ Slet ikke

12. Indtog du følgende umiddelbart inden du faldt i søvn? *Sæt kun ét X*

☐ Ja, sovemiddel ☐ Ja, alkohol ☐ Ja, smertestillende ☐ Nej, ingen af delene

13. Har du i løbet af natten/søvnen haft lyset tændt i samme rum som dig?
Sæt kun ét X

☐ Nej ☐ Ja

Instruktion til lysmåleren Actiwatch

Lysmåleren registrerer intensitet og spektralsammensætningen af det lys du udsættes for, dvs. den registrerer hvor svagt eller kraftigt lyset er samt indholdet af fx blåt eller rødt lys. Derudover registrerer lysmåleren også bevægelse, dvs. at den måler, hvornår du bevæger den arm, som lysmåleren sidder på. Det er ikke muligt at se, hvad du laver, men kun at du bevæger dig. Vi bruger det til at undersøge kvaliteten af din søvn.

Sådan bæres lysmåleren mens du er vågen:

- Lysmåleren bæres på **overarmen** af den dominante arm, dvs. hvis du er højrehåndet, skal du sætte den på højre arm.
- Måleren bæres på overarmen alle 7 dage mens du er vågen.
- Lysmåleren bæres uden på det tøj du har på. Det gælder også overtøj.
- Måleren kan holde til at komme med i bad i op til 30 minutter.

Undgå, at tildække måleren med tøj, hår eller lignende, da det således ikke er muligt at se, hvor meget lys du er blevet udsat for.

Sådan bæres lysmåleren mens du sover:

- Lysmåleren bæres som udgangspunkt på **håndleddet** mens du sover, for at kunne vurdere din søvnkvalitet. Du skal sætte den på din dominante arm, dvs. hvis du er højrehåndet, skal du sætte den på højre arm.
- To nætter skal lysmåleren dog ligge ved siden af dig på et natbord eller et sted ved siden af sengen. Disse to nætter aftales med en projektmedarbejder ved undersøgelsens opstart.
    - Hvis du er dagarbejder skal lysmåleren ligge på natbordet én nat op til en arbejdsdag og én nat op til en fredag. Dvs. to nætter i alt.
    - Hvis du er natarbejder skal måleren ligge på natbordet 1 gang i forbindelse med en nattevagt (dvs. hvor du sover om dagen), og 1 gang i forbindelse med, at du sover om natten.
- Når du vågner, registrerer du i dagbogen ud for det relevante spørgsmål, om lysmåleren har været på håndleddet eller på natbordet ved siden af dig.

Hvad betyder symbolerne på lysmålernes skærm?
I tabellen nedenfor kan du se betydningen af nogle af de vigtigste symboler som lysmålerens skærm kan vise. Hvis du er i tvivl om din lysmåler fungerer korrekt, så kontakt os da venligst via kontaktoplysningerne som du finder på bagsiden af denne dagbog.

Symbol:	Betydning:
	Uret indsamler data og har registreret kontakt med huden.
	Uret indsamler data, men viser ikke klokken, da det ikke kan registrere kontakt med huden.
	Uret har indsamlet data, og har nået det på forhånd programmerede stoptidspunkt.
	**Uret indsamler ikke data.** Kontakt os venligst på mobilnummer **2037 3718** (Århus) eller **2253 4699** (København).

Instruktion til spytprøverne

Det er ikke alle deltagere der skal tage spytprøver. Du vil blive informeret ved starten af undersøgelsen, hvis du er blevet udvalgt til at tage spytprøver.

Hvornår skal du tage spytprøverne?
Du har sammen med den projektmedarbejder, der udleverede undersøgelsesmateriale aftalt, hvilke dage du skal indsamle spytprøver.

Du skal tage max 14 prøver i alt. 7 på en arbejdsdag og 7 på en fridag.

Prøverne tager du:

- I din seng første gang du vågner uanset hvad klokken er. Det er derfor nødvendigt, at du har et rør og en etiket klar ved siden af din seng.
- Derefter tager du en prøve hver 4. time, så det ca. passer med tidspunkterne:
  - Kl. **07**, kl. **11**, kl. **15**, kl. **19**, kl. **23** og kl. **03**

  Spring det tidspunkt over, hvor du sover.
- Sidste gang du tager en prøve er når du lægger dig til at sove, uanset hvad klokken er.

Sådan tager du spytprøverne
Det tager højst fem minutter at tage en spytprøve. Du skal bruge et rør og en etiket til hver spytprøve. Du må **ikke spise ½ time** før prøvetagningen.

1. "Knæk" proppen af røret.
2. Fyld røret med ca. 1 ml spyt (til mærket) – det tager ca. to minutter. Lad det tynde spyt løbe ned i røret eller skub det ned i røret med tungen. Tænk på en citron, hvis du er tør i munden.
3. Udfyld etiketten og sæt den på røret.
4. Læg prøven i et køleskab eller en fryser, når du kan komme til det.

Du kan aflevere spytprøverne sammen med spørgeskemaerne og lysmåleren, når vi efter de 7 undersøgelsesdage kommer ud på din arbejdsplads igen.

LUX@R udføres i et samarbejde mellem Arbejdsmedicinsk Klinik ved Aarhus Universitetshospital, Det Nationale Forskningscenter for Arbejdsmiljø, Statens Byggeforskningsinstitut, VELUX A/S, Arbejds- og Miljømedicinsk Afdeling ved Bispebjerg Hospital samt Aarhus Universitetshospital, Risskov.

Arbejdsmedicinsk Klinik, Aarhus Universitetshospital
Nørrebrogade 44, Bygning 2C
8000 Aarhus C
Telefon: 7846 4291
Projektmobil: 2037 3718

Det Nationale Forskningscenter for Arbejdsmiljø
Lersø Parkallé 105
2100 København Ø
Telefon: 3916 5258
Projektmobil: 2253 4699

Bilag 5. Afslutningsskema til Arbejdsmiljøforskningsfonden

Afslutning på projekt

Indsendes til:
forskningsfonden@at.dk

Generelle oplysninger om projektet

1	**Projektets titel**
	Helbredskonsekvenser af lysmiljøet ved indendørs- og natarbejde, Lux@r-projektet

2	**Ansøger**	
	CVR-nummer:	29762929
	Institutionens navn:	Arbejdsmedicinsk Klinik, Aarhus Universitetshospital
	Arbejdsadresse:	Nørrebrogade 44, Bygning 2C
	Tlf.nr.:	7846 4290
	e-mail:	henkol@rm.dk

3	**Ansvarlig projektleder/kontaktperson**	
	Navn:	Henrik Kolstad
	Arbejdssted:	Arbejdsmedicinsk Klinik, Aarhus Universitetshospital
	Arbejdsadresse:	Nørrebrogade 44, Bygning 2C
	Tlf.nr.:	7846 4285
	e-mail:	henkol@rm.dk

4	**Projektet formål og hovedhypoteser** (Kortfattet beskrivelse af projektets formål og hovedhypoteser herunder begrundelse for evt. ændringer i formål og hovedhypoteser):
	Det overordnede formål med LUX@R-projektet var at undersøge om lysmiljøet ved indendørsarbejde og natarbejde har helbredsmæssige konsekvenser: 1) Om udsættelse for lave niveauer af lys om dagen ved indendørsarbejde giver forøget risiko for depression, søvnforstyrrelser og almensymptomer. 2) Om udsættelse for høje niveauer af lys om natten ved natarbejde giver forøget risiko for brystkræft. 3) Om udsættelse for lave niveauer af lys ved indendørsarbejde og høje niveauer af lys ved natarbejde ændrer den biologiske døgnrytme.

5	**Resultater og videnskabelig nyhedsværdi** (Redegør for de videnskabelige resultater af projektet og deres nyhedsværdi. Redegør desuden for hvilke resultater der var forventede henholdsvis uventede. Hvordan forholder resultaterne sig til øvrige forskningsresultater?):
	Vi fandt ingen forøget risiko for brystkræft ved nyligt natarbejde blandt af 155.569 kvinder ansat i danske regioner mellem 2007 og 2012. Dette fund og den metodemæssige tilgang har videnskabelig nyhedsværdi. I 2007 klassificerede the International Agency of Cancer (IARC) natarbejde som sandsynligt kræftfremkaldende for mennesker baseret bl.a. på epidemiologiske studier. Disse undersøgelser var dog behæftet med større metodemæssige svagheder, primært informationsbias relateret til selvrapporterede eksponeringsoplysninger. Det tog vi højde for ved at anvende præcise dag-til-dag arbejdstidsoplysninger fra lønregistre, som vi koblede bl.a. med cancerregistre og en række andre offentlige registre. Undersøgelsen var dog begrænset af, at vi ikke havde oplysninger om, og dermed ikke kunne vurdere evt. risiko af, længere tids natarbejde eller det at have haft natarbejde for mere end 5 år siden. Vi har undersøgt om natarbejde nedsætter melatonin koncentrationen (døgnrytme hormon) i spyt på dage med natarbejde og på fridage blandt 341 natarbejdere, udendørsarbejdere og indendørs dagarbejdere. Alle deltagere blev fulgt tæt gennem en uge med kontinuerlig målinger af lysniveauer, spytprøver, som blev analyseret for melatonin, og dagbogsregistreringer af bl.a. arbejdstider. Vi analyserede om udsættelse for lys medierer sammenhængen mellem natarbejde og melatonin koncentrationen i spyt. Dette har ikke tidligere været undersøgt blandt natarbejdere, når de udfører deres sædvanlige arbejde. Analyserne viste at melatonin koncentrationen var lavere på dage med natarbejde end på dage med dagarbejde og at denne forskel blev delvist medieret af lysniveauet om natten, men det var få natarbejdere, som var udsat for høje lysniveauer, når de var på nattevagt. Vi fandt ingen forskel i melatonin niveaer mellem dag og natarbejdere på fridage. Vi kunne således konkludere at natarbejde har en forbigående effekt på melatonin, som delvist medieres af lys, og at de fleste natarbejdere i dette studie var udsat for lave lysniveauer, når de var på vagt. I denne gruppe af natarbejdere, udendørs dagarbejdere og indendørs dagarbejdere har vi også undersøgt om forekomsten af depressive symptomer og søvnlængde hænger sammen med lysniveauet. Analyserne dannede grundlag for en master afhandling ved den Sundhedsfaglige Kandidatuddannelse og en bachelor afhandling i Public Health Sciences, begge ved Health, Aarhus Universitet, men har endnu ikke været gennem fagfællesbedømmelse i et videnskabeligt tidsskrift. Vi har kortlagt lysniveauerne på arbejdsdage og fridage for 535 natarbejdere, udendørs dagarbejdere og indendørs dagarbejdere. Resultaterne har været fremlagt ved videnskabelige konferencer, et manuskript er under fagfællebedømmelse ved et internationalt tidsskrift og resultaterne vil danne grundlag for fremtidige analyser af depression og andre helbredseffekter, hvor lys kan være en risikofaktor, i hele den arbejdende danske befolkning.

6	**Arbejdsmiljøperspektiver (**Hvilken relevant viden er der skabt i projektet? Hvilken betydning har det for arbejdsmiljøet og arbejdsmiljøarbejdet? Kan projektets resultater omsættes til praktisk anvendelse for målgrupperne? Hvordan kan resultaterne overføres til andre målgrupper?)
	Vores resultater vedrørende nyligt natarbejde og brystkræft er beroligende og vil indgå i den samlede vurdering af om natarbejde skal klassificeres og reguleres som kræftfremkaldende. Analyserne af melatonin tyder ikke på en vedvarende effekt natarbejde og dette understøtter konklusionen på analyserne af brystkræft. Dette vil få indflydelse på fremtidige anbefalinger om tilrettelæggelse af natarbejde, som kan få betydning for de mange, som ikke kan undgå at arbejde om natten. Fundene vedrørende lyseksponeringsniveauer er bl.a. relevant for de mange, som har indendørsarbejde og arbejder under lave dagslysniveauer, og kan fx få indflydelse på fremtidig design af indendørs arbejdspladser. Samlet set giver resultaterne ikke anledning til at ændre på de nuværende anbefalinger om at minimere mængden af natarbejde og antallet af nattevagter i træk.

7	**Medarbejdere** (angiv navne på videnskabelige medarbejdere i projektet)
	1. Anne Helene Garde, NFA 2. Åse Marie Hansen, NFA og KU 3. Jens Peter Bonde, BBH, 4. Jens Christoffersen, Velux A/S 5. Jakob Markvart, SBI, AaU 6. Helene Tilma Vistisen 7. Stine Daugaard Pedersen 8. Morten Frydenberg, AU 9. Peer Christiansen, AUH, 10. Johnni Hansen, KB 11. Vivi Schlünssen, AU og NFA 12. Jesper Medom Vestergaard 13. Deborah Skene, University of Surrey, UK 14. Ida Katrine Thomsens AU 15. Ann Erikson, AU.

8	**Øvrige institutioner** (angiv øvrige institutioner som har deltaget i projektet)
	1. Det Nationale Forskningscenter for Arbejdsmiljø (NFA) 2. Københavns Universitet 3. Velux A/S, 4. Statens Byggeforskningsinstitut, Aalborg Universitet 5. Aarhus Universitet 6.Kræftens Bekæmpelse 7. Chronobiology, Faculty of Health and Medical Sciences, University of Surrey, Guildford, United Kingdom

9	**Interessentgruppe** (Angive navne på medlemmer af evt. interessentgruppe)

10		
	Startdato for projektet:	1.1 2011
	Planlagt slutdato:	31.12.2013
	Faktisk slutdato:	31.12. 2016

Formidling (Ved fortrolighed skal denne aftales med Arbejdsmiljøforskningsfondens sekretariat inden indsendelse af slutrapporten.)

11	**Har Videncenter for Arbejdsmiljø været inddraget i formidling undervejs i projektforløbet?**	**Nej** ☐ **Ja** x☐

12	**Populærformidling (mundtlig)**	
	Konferencer, seminarer m.v.:	Henrik Kolstad. Skal vi undgå natarbejde for at forebygge brystkræft? Temadag om helbred og natarbejde, Region Midtjylland. 15. marts 2011 kl. 12.30-16. på Scandic Hotel Silkeborg Henrik Kolstad. For meget og for lidt lys ved natarbejde og indendørsarbejde, betyder det noget for helbredet? Lys som forbedrer sundhed & trivsel i hospitalssektoren. SBI konference. København: 22. november, 2011 Henrik Kolstad. Night shift work and risk of breast cancer – review of the epidemiological evidence up to 2007 requested by the Danish National Occupational Injury Board. Work at night and breast cancer: Evidence-based options for preventive actions, Copenhagen, October 26-27, 2011. Henrik Kolstad. Natarbejde og brystkræft: Evidensbaserede forebyggelsesmuligheder. Regionshospitalet Viborg 13. august 2012, Hovedmed udvalget (HMU) ved Aarhus Universitetshospital, 24. september 2012 og Regionshospitalet Randers 3. oktober 2012 Henrik Kolstad. Årlige informationsmøder om natarbejde og helbred for ansatte i Region Midtjylland
	Målgruppe for de væsentligste aktiviteter (max 5):	1. Natarbejdere og deres arbejdsgivere samt deres respektive organisationer. 2. Arbejdstilsynet 3. Arbejdsmarkedets Erhvervssikring 4. Forskningsmiljøer beskæftiget med døgnrytme og helbred

11	**Populærformidling (skriftlig)**	
	Projektets populær-videnskabelige artikel:	
	Øvrige artikler, nyheder m.v.: (Angiv titel og medie) **Hjemmeside/sociale medier:**	Kom i godt humør med udendørs arbejde . Videnskab.dk., 13. april 2011. (www.videnskab.dk/krop-sundhed/kom-i-godt-humor-med-udendorsarbejde) Lys som den store humørspreder, Arbejdsmiljøviden, 23. august 2011 (www.arbejdsmiljoviden.dk/Aktuelt/Nyheder/2011/08/23-lys-projekt) Gør lys os virkelig i godt humør? Videnskab.dk, 11 august 2011 (www.videnskab.dk/krop-sundhed/gor-lys-os-virkelig-i-godt-humor) Det måske farlige natlys. Midtnyt, november 2012. Lys spreder humør på jobbet. BAR transport og engros: dato? (www.bartransportogengros.dk/Default.aspx?ID=3669&M=News&PID=7157&NewsID=3463) Kortvarigt natarbejde øger formentlig ikke risiko for brystkræft. Videnskab.dk, 2.12.2016. (http://videnskab.dk/krop-sundhed/kortvarigt-natarbejde-oeger-formentlig-ikke-risiko-for-brystkraeft) Ny AUH-forskning viser, at natarbejde i en kort årrække ikke øger risiko for brystkræft. Kræftens Bekæmpelse 6.12.2016. (https://www.cancer.dk/Nyheder/Presseklip/?resultsPerPage=100). Få års natarbejde giver ikke øget risiko for brystkræft. Mit arbejdsmiljø februar 2017. (https://mitarbejdsmiljo.dk/artikler/faa-aars-natarbejde-giver-ikke-oeget-risiko-brystkraeft) Resultaterne om brystkræft har været præsenteret på møder for Arbejdstidsfølgegruppe (januar 2017) og DAD følgegruppe (marts 2017).

12	**Videnskabelig formidling (mundtlig)**

Oplæg på konference, seminarer m.v. (angiv konference og titel på oplæg):

Vistisen HT. Night work and breast cancer risk among women in the public Danish Health care sector: a short-term follow up of a large scale population. The 24th International Epidemiology in Occupational Health (EPICOH) Conference, June 24-27, 2014, Chicago, IL.

Stine Daugaard. ISEE Indoor work, ultraviolet radiation, light exposure, and the risk of depression and multiple sclerosis. Young Researchers Conference on Environmental Epidemiology, Barcelona Oct 2014

Henrik Kolstad, Pascal Guenel, Mikko Härma, Jørn Olsen. Symposium: Epidemiology of shift work, breast cancer, and other health effects. Aarhus University, Aarhus: December 18; 2015

Kolstad HA. Short term risk of breast cancer following night shift work in the public healthcare sector: a register linkage study of pay roll data. The 22nd International Symposium on Shiftwork and Working Time. Helsingør: 08/06/2015

Stine Daugaard. Night work, light exposure, and melatonin on work days and days off, PH.D day Aarhus University: January 2016

Stine Daugaard. Occupational Light Levels in Night Shift, Outdoor, and Indoor Daytime Workers, The 25th International Epidemiology in Occupational Health (EPICOH) Conference, September 2016, Barcelona

Henrik Kolstad. Strategies for the prevention of the health effects of night shift work. Panel discussion, The 25th International Epidemiology in Occupational Health (EPICOH) Conference, 2016, Barcelona
Stine Daugaard. Night work, light exposure, and melatonin on work days and days off, Ramazzini Seminar, Sandbjerg: October 2016

Stine Daugaard. Night work, light exposure, and melatonin on work days and days off. WINC-WOW symposium. Stress Research Institute, Stockholm University, 17.11.2016

Henrik Kolstad. Short term effects of night shift work on breast cancer risk: a cohort study of payroll data. WINC-WOW symposium. Stress Research Institute, Stockholm University: 17.11.2016

Jakob Markvart. Light exposure assessment of Danish indoor, outdoor and night-shift workers - Experiences from a field study Workshop Light, health and shift work. Dortmund: October 13, 2016

Stine Daugaard Pedersen. Occupational light exposure, melatonin and vitamin D. EPICOH 2017: 26th International Epidemiology in Occupational Health. Edinburgh, Storbritannien. 28-31 aug. 2017

13	**Videnskabelig formidling (skriftlig)**

Peer reviewede artikler (angiv titel og tidsskrift m.v.):
Bonde JP, Hansen J, Kolstad HA, Mikkelsen S, Olsen JH, Blask DE, Härmä M, Kjuus H, de Koning HJ, Olsen J, Møller M, Schernhammer ES, Stevens RG, Åkerstedt T. Work at night and breast cancer--report on evidence-based options for preventive actions. Scand J Work Environ Health. 2012 Jul;38(4):380-90.

Markvart J, Hansen ÅM, Christoffersen J. Comparison and Correction of the Light Sensor Output from 48 Wearable Light Exposure Devices by Using a Side-by-Side Field Calibration Method. LEUKOS: The journal of the Illuminating Engineering Society of North America.2015: 155-171.

Garde AH, Hansen J, Kolstad HA, Larsen AD, Hansen AM. How do different definitions of night shift affect the exposure assessment of night work? Chronobiol Int. 2016;33(6):595-8.

Vistisen HT, Garde AH, Frydenberg M, Christiansen P, Hansen AM, Hansen J, Bonde JP, Kolstad HA. Short-term effects of night shift work on breast cancer risk: A cohort study of payroll data. Scand J Work Environ Health. 2016 Nov 14

Daugaard S, Garde AH, Bonde JPE, Christoffersen J, Hansen AM, Markvart J, Schlunssen V, Skene DJ, Vistisen HT, Kolstad HA. Night work, light exposure and melatonin on work days and days off. Chronobiol Int. 2017;34(7):942-55.

Øvrig skriftlig videnskabelig formidling (fx bogkapitler):
(Angiv titel og medie):

Vistisen HT. Short term effects of night shift work on risk of overall breast cancer and breast cancer classified by oestrogen and HER2 receptor status PhD dissertation, Health, Aarhus University, 2015.

Ida Katrine Thomsen. Low Levels of Light Exposure at Work and Risk of Depression. Master Thesis. Den Sundhedsfaglige Kandidatuddannelse, Health, Aarhus University: 2015.

Anna Huus Eriksson. Morning Light Exposure on Workdays and Self-Reported Sleep Duration: A Cross-Sectional Study on Danish Day workers. Bachelor Thesis Bsc programme in Public Health Sciences, Aarhus University: 2016

Kolstad HA, Garde AH, Hansen AM, Frydenberg M, Christiansen P, Vistisen HT, Bonde JP. Response to Dr. Stevens' letter ref. Visitisen et al: "short-term effects of night shift work on breast cancer risk: A cohort study of payroll data". Scand J Work Environ Health. 2017 Jan 1;43(1):96.

Stine Daugaard Pedersen. Occupational light exposure, melatonin, and vitamin-D. PhD dissertation, Health Aarhus University, 2017

Manuskripter indsendt til videnskabeligt tidsskrift eller under udarbejdelse

S. Daugaard, AH. Garde, JP. Bonde, J. Christoffersen, AM. Hansen, J. Markvart, V. Schlünssen, HT. Vistisen, HA. Kolstad. Light exposure levels during days with night, outdoor, and indoor work and days off.

14	**Projektansvarliges underskrift og dato** Undertegnede erklærer, at ovenstående oplysninger og oplysningerne i bilag er rigtige. Hvis der er afgivet urigtige eller vildledende oplysninger i ansøgningen, eller hvis oplysninger, som kan have betydning for afgørelse om tilsagn, er tilbageholdt, kan et tilsagn annulleres, og evt. udbetalinger kræves tilbagebetalt.
	Aarhus, 8/1/2018 

Bilag 6. Dokumentation af LUX@R databasen

Table 2. Contents of the LUXAR database, 2012-2013 Revised 2018-01-05

Description	Content	Source	Observations (No.)	Subjects (No.)	Data file
What did the participant do each minut of the study week	Work, Leisure, Sleep, Awake in bed, Transport (the hour before and after work), Sleep during work, Awake in bed during work	Diary	4.980.898	534	Aktivitet.dta
Bloodsamples	Date and time bloodsample was taken		459	459	Blodprøver.dta
Which participants had 25OHD analysed	Plasma PTH, Serum 25OHD,Calcium, Creatininium, and Albumin	Serum and Plasma	451	451	Blodprøversamlet.dta
Which participants had BDNF and ProBDNF blood analyses	BDNF and ProBDNF	Serum	449	449	bdnf_samlet.dta
Which participants have had taken blood samples	Biobank with: Buffy Coat, serum (3x1ml), EDTA plasma (3x1ml), fuldblod	Venous blood samples collected mainly during the first day of the 8-day study period.	459	459	Coolbase.dta
Where are blood samples stored for each participant	Container, rack, box, shelf and time bloodsample was stored	Coolbase	4.093	459	Coolbase placering.dta
7 day diary	Information about work time, leisure time and sleep	Self-completed diaries filled in by the participants twice a day: after awakening and before bedtime.	534	534	Dagbog_f.dta

Description	Content	Source	Observations (No.)	Subjects (No.)	Data file
7 day diary	Information about medication and caffeine before bedtime, physic activity during work and leisure, and outdoor stay during work and leisure	Self-completed diaries filled in by the participants twice a day: after awakening and before bedtime.	534	534	Dagbog_g.dta
Participant information	Actiwatchnr., CPR-nr., name and address of workplace, skin type, time of blood sample collection and freezing of the blood samples	Information recorded by members of the project team.	576	563	Deltagere_a.dta
Participant information	Actiwatchnr., skin type, time of blood sample collection and freezing of the blood samples	Information recorded by members of the project team.	534	534	Deltagere_b.dta

Description	Content	Source	Observations (No.)	Subjects (No.)	Data file
Participants classified as indoor, outdoor and night workers.	Night workers classified based on selfreported night work. Outdoor workers selfreported minimun 2 hours outside during working hours for minimum 2 days. Or if they only provided one workday during the study period with 2 or more hours outdoors. Indoor workers did not fulfill the criteria of either outdoor or night worker	Diary and Questionnaire	534	534	deltager_jobgroup.dta
Raw light measurements merged with diaries and cleaned up	Red, blue, green and white light, and activity.	Collected by use of 'Actiwatch Spectrum 2'	4.980.898	534	Lys.dta
Mean and median white light per hour and participant.	Mean and median white light	Collected by use of 'Actiwatch Spectrum 2'	83.416	534	lys_grupperet.dta
Mean and median white light per day and participant.	Mean and median white light	Collected by use of 'Actiwatch Spectrum 2'	4.090	534	lys_mean_dato.dta

Description	Content	Source	Observations (No.)	Subjects (No.)	Data file
Mean white light per minut of the day/participant.	Total white light per minut of the day divided by number of days with measurements this minut.	Collected by use of 'Actiwatch Spectrum 2'	763.970	534	lys_mean_minut.dta
Questionnaire data	Information about work title of main and second job, usual working hours, outdoor work during winter, spring, summer and fall, physical demands during work, total years of shift work, health and lifestyle, sleep pattern, chronotype.	Self-completed questionnaire filled in by the participant at home.	534	534	Sporgeskema
Which participants has handed in saliva samples	Saliva samples cortisol, melatonin and testosterone levels	Saliva samples collected by the participants during 1 work day and 1 day off. Saliva samples were collected at awakening and at 7, 11, 15, 19, 23, and 03 whenever awake. A final sample was collected just before bedtime.	3.835	408	Spytprøveresultater_a

Description	Content	Source	Observations (No.)	Subjects (No.)	Data file
Which participants has handed in saliva samples and results from analysis. Samples with unknown time of sampling, unknown activity, and missing results of all three hormones are excluded.	Saliva samples cortisol, melatonin and testosterone levels	Saliva samples collected by the participants during 1 work day and 1 day off. Saliva samples were collected at awakening and at 7, 11, 15, 19, 23, and 03 whenever awake. A final sample was collected just before bedtime.	3.559	402	Spytprøveresultater_b