Extended workdays, compressed work periods, fatigue and cardiovascular strain

A study of health care workers and airline crew

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2019

STAMI NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH

UiO Faculty of Medicine University of Oslo

Series of dissertations submitted to the
Faculty of Medicine, University of Oslo

ISBN 978-82-8377-632-4

Cover: Hanne Baadsgaard Utigard.
Print production: Reprosentralen, University of Oslo.

Content

Acknowledgements

This project is the result of several people′s effort during a four-year period. I would like to express my sincere gratefulness to all!

I would like to start by thanking my supervisor Jenny-Anne Sigstad Lie in the department of Occupational Medicine and Epidemiology at STAMI. You have most patiently shared your experience and extensive knowledge with me. You have been a rock during this work; always willing to give me advice, guidance, constructive criticism, and not the least, never ending support. Thanks also for all the fun we have shared during these years!

I am also grateful to Anthony Wagstaff who believed in me, and asked me to join the project group initially. In addition to being my supervisor at University of Oslo, he has contributed with in-depth aeromedical knowledge, editing of the manuscripts, improvement of language, and always being there when I had questions or needed support.

Thanks to the head of the department of Occupational Medicine and Epidemiology at STAMI, Karl-Christian Nordby, for always being enthusiastic and supportive, and for your contribution to the acquisition of the data, and for thoroughly editing the manuscripts.

I would also express my gratitude to the co-authors in the project: Mika Tarvainen has contributed to the visual inspection of the raw HRV-data, and to the analyses, in addition to editing two of the manuscripts. Susanna Järvelin-Pasanen has given valuable input to the editing of two of the papers. Lars Ole Goffeng has contributed to the conception and design of the project, data collection, the analyses of the neurobehavioral tests, and editing of two of the manuscripts. Merete Bugge has contributed to the conception and design of the project, and to the editing of the first paper. Anders Meland has given instructions on how to measure HRV, and constantly being available to answer questions, in addition to providing valuable input to the editing of one of the manuscripts. Thanks to you all!

A very special thanks to Øivind Skare, who have patiently led me into “the fascinating world” of statistics, in addition to his sound and humorous way of pointing out the importance of other things in life than the PhD-project.

Thanks to all the participants; health care workers, cabin crewmembers and pilots, who have provided valuable information for the study. I would also like to express my sincere thanks to the management of Cabin- and Flight Operation in the airline, the pilot- and cabin crew unions for their support and helpfulness in making this project possible. A special thanks to the director of Cabin Operations, Merete Elvestad, who believed in, and supported the project from the very start.

I would also like to thank STAMI, UiO and The Norwegian Confederation of Trade Unions (LO) for funding this study.

Last, but not least I would like to express my gratefulness to Lars for being both my supportive husband and colleague. Your enthusiastic encouragements during this work has been invaluable! Thanks also to Gudrun, Marit, Anne and Emma; my wonderful daughters who make everything worthwhile.

1 Abbreviations and explanations

ACT Attentional Capture Task

BMI Body Mass Index (kg/m^2)

BSL Bestemmelser for Sivil Luftfart (Civil Aviation Regulations)

CAA Civil Aviation Authorities

CI Confidence Interval

CVD Cardiovascular Disease

EU-OPS European Regulatory Framework

FDP Flight Duty Period

FTL Flight Time Limitation

FRMS Fatigue Risk Management System

GP General Practitioner

HF High Frequency

HR Heart Rate

HRV Heart Rate Variability

ICAO International Civil Aviation Organization

LMM Linear Mixed Models

LF Low Frequency

PVT Psychomotor Vigilance Test

RR The Beat-to-Beat Interval

RT Reaction Time

RMSSD Root Mean Square of the Successive Differences

SART Sustained Attention to Respond Task

SDNN Standard Deviation of Normal to Normal R-R intervals

SPSS Statistical Methods for Social Sciences

SP Samn-Perelli Fatigue Check-list

STAMI National Institute of Occupational Health

2 Summary

The development of the "24-hour society" has called for increased flexibility and increased use of night- and shiftwork plus extended working hours. Extended working hours are particularly stressful if there is insufficient time for recovery between shifts or working periods, which seems to be an influencing factor in the association between long working hours and adverse health and safety outcomes.

The organization of working hours influences biological and social rhythms, sleep, recovery, and circadian rhythms. Work-related *fatigue* is defined as an extreme tiredness and impaired functioning during and at the end of the working day, and can occur if there is insufficient time for rest and recovery between shifts and work periods. Fatigue has been identified as a factor contributing to accidents, injuries and death in a wide range of settings. Workplace accidents and adverse incidents in aviation and healthcare can, in addition to being detrimental for the worker, represent a risk to third parties, such as passengers and patients.

Exposure to stressful events will evoke responses in the cardiovascular system, and extended workdays may represent an external stressor causing increased activity in the sympathetic nervous system.

The main aim of this thesis was to investigate whether long working hours and compressed work periods indicate risk factors for fatigue-related errors as measured by neurobehavioral tests and cardiovascular strain as indicated by HRV measurements, among healthcare workers, airline pilots and cabin crew members.

Heart rate variability was measured during work, leisure time and sleep. Different HRV-parameters were analyzed (RR, RMSSD, SDNN, LF/HF).

Among the pilots and cabin crew members, fatigue was estimated using two neurobehavioral tests: Sustained Attention to Response Task and Attentional Capture Task (ACT), where errors, precision and reaction time were calculated.

Background information about the participants was obtained through a questionnaire before start-up, and through work and sleep diaries during the working period. Data was collected from the healthcare workers during spring and autumn 2014, from the cabin crew members during spring and autumn 2015, and from the pilots during autumn 2015, spring and autumn 2016, and spring 2017.

Among the healthcare workers, HRV-variables indicated significantly higher cardiovascular strain throughout the first working day compared to the fourth. Among the pilots, a significant association was observed between high workload and indications of increased cardiovascular strain during the entire work period. Among cabin crew members, we found that increased sleep duration before and longer duration of breaks during a working day resulted in significant reduction of such strain. Nocturnal measurements of HRV indicate that participants from all three groups recovered well after the extended working days and the compressed working period. Results from the neurobehavioral tests showed no significant change in performance due to working hours alone, either among pilots or cabin crew members. However, a significantly increased response time was observed with an increasing number of flights included in the four-day working period, both among pilots and cabin crew members.

Reported sleep duration before and fatigue during the workdays did not seem influence neurobehavioral performance in either pilots or cabin crew members.

Mixed findings in the three occupational groups indicate that work hours and shift schemes only explain some of the response patterns in the study, and that conditions related to work tasks also appear to be relevant predictors of cardiovascular strain and fatigue. Further research is required to investigate the complex interaction between such predictors.

3 Summary in Norwegian

Utviklingen av et «24-timers samfunn» har omfattet større variasjon i, og mindre forutsigbar arbeidstid, økt bruk av natt- og skiftarbeid, og lengre arbeidsøkter. Utvidet arbeidstid er spesielt belastende dersom det ikke er tilstrekkelig tid til hvile mellom arbeidsøktene, noe som ser ut til å være av betydning for sammenhengen mellom lange arbeidsøkter og negative helse- og sikkerhetsutfall.

Skiftordninger påvirker biologiske og sosiale rytmer, søvn, restitusjon og døgnrytmer. Arbeidsrelatert *fatigue* er definert som ekstrem tretthet og redusert funksjonsevne under og ved slutten av arbeidsdagen, og kan oppstå dersom det er utilstrekkelig tid til hvile og restitusjon mellom skift og arbeidsperioder. Fatigue har vært en medvirkende faktor til ulykker, skader og dødsfall i mange sammenhenger. Arbeidsulykker og feilhandlinger innen luftfart og helsevesen kan, i tillegg til å skade den ansatte, representere en risiko for tredjeparter, som passasjerer og pasienter.

Eksponering for stressende hendelser vil fremkalle reaksjoner i hjerte- og karsystemet. Lange arbeidsdager kan utgjøre en ekstern stressor, som medfører økt aktivitet i det sympatiske nervesystemet.

Hovedformålet med denne studien har vært å undersøke om lange arbeidsdager og komprimerte arbeidsperioder representerer risikofaktorer for feilhandlinger og for økt hjerte-karbelastning blant pleiere, flygere og kabinbesetningsmedlemmer.

Vi målte hjerteratevariabilitet (HRV) på alle deltakerne under arbeid, fritid og søvn. HRV-målene inkluderer i tillegg til puls, flere avledede mål (RMSSD, SDNN, LF, HF, LF/HF).

Som et uttrykk for fatigue hos piloter og kabinbesetningsmedlemmer, ble antall feiltrykk, presisjon og reaksjonstid registrert gjennom to nevropsykologiske tester: Sustained Attention to Response Task og Attentional Capture Task.

Bakgrunnsinformasjon om deltakerne ble innhentet ved spørreskjema før oppstart, og gjennom arbeids- og søvndagbøker i løpet av arbeidsperioden.

Datainnsamlingen blant pleierne ble gjennomført vår og høst 2014, blant kabinbesetningsmedlemmene vår og høst 2015, og blant flygerne i løpet av høsten 2015, samt vår og høst 2016 og våren 2017.

Blant helsepersonell viste HRV-variablene tegn på signifikant høyere belastning på hjerte-karsystemet (kardiovaskulært stress) gjennom hele den første arbeidsdagen sammenliknet med den fjerde.

Blant pilotene fant vi en signifikant sammenheng mellom høy arbeidsmengde og tegn på økt kardiovaskulært stress, som gjaldt for hele arbeidsperioden. Blant kabinbesetningsmedlemmene fant vi at økt søvnlengde før en arbeidsdag, og lengre varighet av hvilepauser i løpet av arbeidsdagen medførte en signifikant reduksjon av slik belastning. Nattlige målinger av HRV tyder på at deltakere fra alle tre gruppene fikk restituert seg godt etter de lange arbeidsdagene og den komprimerte arbeidsperioden.

Resultater fra de nevropsykologiske testene viste ingen signifikante endringer mht prestasjon som følge av arbeidstid alene, verken blant flygere eller kabinbesetningsmedlemmer. Vi fant imidlertid en signifikant økt reaksjonstid med økende antall flyvninger som var inkludert i arbeidsperioden, mens presisjonsnivået forble uendret. Dette gjaldt både flygere og kabinbesetningsmedlemmer.

Verken rapportert søvnlengde før arbeidsdagene, eller fatigue i løpet av arbeidsdagene påvirket funksjon blant noen av de flygende.

Ulike funn i de tre yrkesgruppene indikerer at arbeidstimer og skiftordninger bare forklarer noen av svarmønstrene i studien, og at forhold knyttet til jobbinnhold også ser ut til å være relevante prediktorer for hhv kardiovaskulært stress og fatigue. Det er derfor behov for ytterligere forskning for å undersøke det komplekse samspillet mellom ulike faktorer som kan bidra til slike utfall.

4 List of publications

Paper I

Elisabeth M. Goffeng, Karl-Christian Nordby, Mika P. Tarvainen, Susanna Järvelin-Pasanen, Anthony Wagstaff, Lars Ole Goffeng, Merete Bugge, Øivind Skare, Jenny-Anne S. Lie. ***Fluctuations in heart rate variability of health care workers during four consecutive extended work shifts and recovery during rest and sleep.*** Industrial Health 2018, 56, 122-131.

Paper II

Elisabeth M. Goffeng, Anthony Wagstaff, Karl-Christian Nordby, Anders Meland, Lars Ole Goffeng, Øivind Skare, Didrik Lilja, Jenny-Anne S. Lie. ***Risk of fatigue among airline crew during four consecutive days of flight duty.*** Aerospace Medicine and Human Performance Vol. 90, No. 5 May 2019, pp 466-474.

Paper III

Elisabeth M. Goffeng, Karl-Christian Nordby, Anthony Wagstaff, Mika Tarvainen, Susanna Järvelin-Pasanen, Øivind Skare, Jenny-Anne S. Lie. ***Cardiac autonomic activity in commercial airline crew during an actual flight duty period***. Submitted a revised version to Aerospace Medicine and Human Performance Vol. 90, No. 11, Nov 2019, pp 945-952.

Photo. **Health care worker (rugiz.com), pilots and cabin crew members (snl.no)**

5 Introduction

The organization of working hours has undergone radical changes within the last few decades, and non-standard working hours are becoming an increasingly prominent aspect of modern society. Non-standard working hours may encompass all forms of working hours outside the 8-hour day and 40-hour week[1]. The development of the "24-hour society" has called for increased flexibility, increased use of night- and shift work, and increased complexity of work time arrangements in many sectors [1, 2]. The demand for such working hours is, to a great extent, a consequence of globalization and increased competition. Economic globalization influences the labor market and work organization, which in turn influence aspects such as demands, job control, effort-reward balance, job security, and duration of working hours [3]. The organization of working hours influence both biological and social rhythms. Sleep, hormones, recovery, and circadian rhythms are highly influenced by the organization of working hours [4, 5]. Working nights, early mornings, and late evenings may cause disruption of the normal circadian rhythm. Circadian rhythms are generated by endogenous oscillators to allow organisms to change their behaviors with a period of 24 hours in anticipation for the changing environment of day and night cycle brought about by the Earth's rotation [6].

Disruption of the circadian rhythm is a risk factor for cardiovascular disease [7], and work-related fatigue has been identified as a contributing factor in accidents, injuries and fatalities in a wide range of settings, with the implications that tired people are less likely to secure safe performance and actions [8]. Workplace accidents in aviation and health care may in addition to being detrimental for the worker, also harm third parties, e.g. passengers and patients. However, knowledge of the potential mechanisms behind adverse effects of compressed work periods is still insufficient, [9] even if research has supported the fact that extended daily or weekly working hours may be detrimental to health and safety [10, 11].

5.1 International working hours -a historic flashback

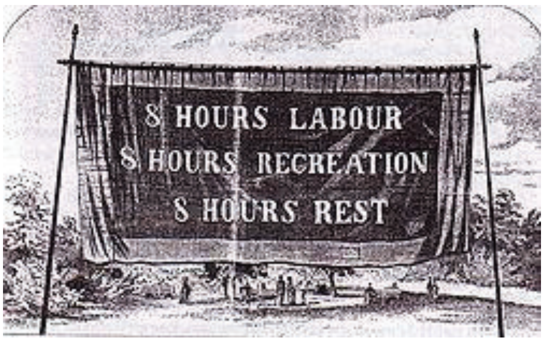


Photo. 8-hour workday (wikipedia.no)

One major achievement in the world's labor history concerning workers health and protection, was the introduction of the eight-hour day. The regulatory limits on working hours evolved in an industrial relations context, aiming to balance working conditions and remuneration [12]. The struggle for the eight-hour day and the 40-hour week was based on the need for balance between work and rest, represented by a social movement, aimed to prevent abuse of workers and maintain their health. Robert Owen, a Welsh social reformer, initiated the movement in the middle of the industrial revolution. Owen raised the demand for an eight-hour day in 1810. Way back in 1817, he introduced the idea of the eight-hour workday and coined the campaign's slogan: "Eight hours labor, eight hours recreation and eight hours rest" [13, 14].

Owen's ideas was met with a fierce opposition by the industrialists, and it would take a century before the industrialized countries in 1919 implemented his ideas, and the first international labor standard on working hours was adopted, which stipulated the principle of the eight-hour day and 48-hour week [15]. By the end of the First World War, the 40-hour working week was implemented by law, and partly by collective agreements in most industrialized countries in Europe and North-America [16]. Establishing common rules for an 8-hour workday/40-hour week was a key task when the International Labor Organization (ILO) was established in 1919 [17]. These regulations are currently considered the norm in most of the industrialized world. It has been claimed, however, that this labor standard represents no more than a "paper tiger", as although stipulated in the law, enforcement in practice is weak.

In 1970, the first comprehensive occupational safety and health legislation was enacted in the USA. Many countries implemented similar legislation throughout the 1970s, introducing a shift from the traditional focus on limits on working hours towards a more general duty of care for managing workplace safety and health in a more integrated manner. UK followed with a Health and Safety at Work Act in 1974, and Norway in 1977. In the Robens Report [18] it was argued that it was as important to focus on the workers safety by setting environmental standards, and addressing particular hazards, rather than focusing on working hours alone. A greater understanding of the various causes of different types of risks and managing risk followed, a comparable progress has been made, as has been the case with the risk of fatigue in aviation [12].

In developing countries as well as in some industrialized countries complaints about long working hours are still common. 'Time squeeze' and 'time poverty' are common concerns [15]. In Japan, a new word has made its way into the dictionary; 'karoshi', meaning "death from overwork", due to the high number of such work-related deaths in recent decades.

5.2 Working hours in Norway

The eight-hour workday was introduced to the work force in Norway in 1919, and was simultaneously incorporated into the Worker's Act. However, in 1968 the Norwegian Parliament decided that large unions could enter into collective agreements on working time "notwithstanding the determined limits of workday length" [19].

Currently, workhours in Norway are regulated according to the Working Environment Act of 2005, last revised in 2015. Daily and weekly workhours are limited to 9 and 40 hours respectively, and the minimum rest between shifts is 11 hours. In most workplaces, collective agreements set a 7.5

hours daily-, and 37.5 hours weekly working time limit.

5.2.1 Extended working hours and compressed work periods

Extended working hours may generally be defined as working hours that exceed normal working hours [20]. The definition of normal workhours differ considerably between industrialized and non- industrialized countries, and as well as within industrialized countries. The most common work schedule is 8 hours per day, 5 days per week, and 48 weeks per year [21]. Extended working hours may either, be part of a regular shift scheme, or an extension of working hours through overtime.

In 2015, a change in the Working Environment Act was introduced, which opened for an average calculation of working hours over a longer time-period. A shift scheme may thus consist of several extended work shifts within either normal, compressed or extended work periods, followed by longer periods off work. The chapter in the Working Environment Act regulating working hours is capped by exemptions. The social partners may enter into agreements regarding exemptions from the regulated workhours and rest requirements within defined limits, but exceeding normal workhours [22]. This has resulted in an increasing number of workplaces with extended daily- and weekly workhours.

In this thesis, “extended workhours” refers to regular working hours exceeding 8 hours per day and 40 hours per week, and “compressed work periods” refers to both normal and extended weekly hours worked in fewer days than the common 5-day week. Compressed work schedules redistributes duty hours over fewer but longer days. This does not necessarily imply any difference in the total time of exposure.

The legal regulations of working time are under constant pressure in order to be adaptable according to the challenges in society. In 2016, a revision of the working time regulations in Norway was suggested, based on increased demand and opportunities for flexibility, both for employees and employers [23].

The continuing changes in the working time regulations emphasize the need of in-depth knowledge as to the potential effects of non-standard working hours, to ensure that the societal needs for flexibility are balanced in relation to negative effects to the health and safety of employees and relevant third parties.

5.3 Working hours among caregivers within the health sector

Photo. The first graduated nurses at the Lovisenberg hospital in Oslo (Lovisenberg 2018.no)

In the current study, the health care workers shift scheme is not in accordance with the weekly limits set in The National Working Environment Act, which is 48 hours if the total number of hours worked in a period of 8 weeks do exceed the hours of a nominal shift schedule, and the weekly hours do not exceed 50 hours. The current nursing home was exempted from these regulation for a period of two years.

Historically, working hours for nurses in Norway were unregulated by law until 1939. Nursing was long considered to be a vocation, and the fight for an 8-hour day for this profession was initiated as late as in 1934. In the first half of the 20th century, nurses in Norway often lived at the premises of the institutions in which they were working, and their life could be compared to nuns living in convents. They had to adhere to strict rules, and until 1939, they were unable to continue as registered nurses if they married. Their shift schemes included, to a large extent, split shifts; morning and evening duty only broken by a short mid-day break. On a weekly basis, their day-time working hours could vary between 54 and 70 hours. Night duty could include 7 to 14 consecutive shifts [24].

Although the 8-hour workday was regulated by law for the Norwegian work force in 1937, the nurses had to wait until 1939 before the 8-hour workday was implemented. From 1939, the nursing profession has been included in the general reductions in working hours along with other employees in Norway [25].

However, during recent years, shift schemes including extended shifts, that have long been in use in the health care sector outside Scandinavia, have also been introduced in nursing homes and hospitals in Norway. The opportunity of an average calculation of working hours over longer periods of time, have brought about a larger diversity in working time arrangements, including compressed work periods and extended shifts. The use of extended shifts allows continuity of care for clients or patients, and is claimed to create a more serene atmosphere in the wards [22]. Many health care workers and nurses prefer these types of shifts as they result in increased time off between work periods and more time for their family, less transportation time and reduced costs for commuting, and fewer shift handovers[26]. However, while the social partners are granting an increasing number of health institutions exemptions from the maximum hours worked and minimum daily rest, they are expressing their concern regarding possible adverse health and safety aspects of such work hours [22].

Photo. **(forskning.no)**

5.4 Working hours in commercial aviation

Photo. (DC-3 snl.no)

Commercial aviation in the Scandinavian countries started prior to World War II, but it did not really take off until 1946 with the establishment of the Scandinavian Airlines System.

International air transportation, has until recently been one of the most regulated of industries. The deregulation of the commercial aviation began with "Open Skies" in the USA by introducing the Airline Deregulating Act in 1978, [27], and tentative "Open Skies Agreements" were implemented among the USA and several EU member states in 2007 and 2008 [28]. In 2012, EU adopted an internal aviation policy, and the following liberalization process has brought about a highly competitive landscape in Europe, and consequently demands for cost reduction as well as an increase in efficiency in order for the airlines to survive in the markets [29]. The nature of work has subsequently changed for employees throughout the industry. Efficiency and productivity in aviation has increased by both an increase in the working hours and increased number of passengers as indicated by rising load factors [27]. Next to fuel costs, labor costs represent the largest single cost factor for the airlines. Substantial savings in operational costs have been reported by using advanced optimization techniques when generating crew rosters[30].

Airline crew members in Norway; both pilots and cabin crew members are exempted from the work hour chapter of The National Working Environment Act. The introduction of the common European legislation for flight time limitations (EU-OPS) replaced the national legislation in Norway, thus allowing for planned

Photo. Airline crew members (sasgroup.net)

daily working hours of up to 13 to 14 hours, and with a weekly limitation of 60 hours. The daily working hours may be extended to 16 hours in unforeseen circumstances. However, the 60 hour weekly limit may not be exceeded. The Civil Aviation Authority (CAA) supervises that the airlines act in compliance with EU-OPS.

The change in legislation, in addition to an extreme competitive market made it difficult for unions to maintain their collective agreements that stated work hours well within the new legislative limits. In 2012, the company that employs the participants in this study were threatened by bankruptcy, and both pilots and cabin crew signed collective agreements that lowered their incomes, changed pension plans, and last, but not least, increased both daily and weekly workhours substantially. In addition, the limits for the number of sectors per a day were increased, and time for rest and recovery reduced. The collective agreements continued to be negotiated every second year after this, however, only minor changes have been made since.
Extended work hours are common in all flight operations in the industry, - both short- and long-haul flights. In addition to the extended work hours, long haul operations often includes both night work and crossing of time zones.

5.5 Health and safety aspects of extended working hours and compressed work periods

5.5.1 Sleep/wake cycle

A primary challenge of extended shifts and compressed work periods is the potential for sleep, wake and work times to be in conflict with the biological regulation of sleep, wakefulness, and alertness [31]. The human sleep/wake cycle is generated through interactions of circadian rhythmicity, a sleep/wake oscillatory process (sleep homeostasis), circadian photoreception, as well as feedback from the sleep/wake cycle on these processes. Alterations in these processes may lead to sleep and wakefulness occurring at abnormal clock times and/or out of phase with endogenous circadian rhythms. Sleep debt increases during wakefulness and dissipates during sleep [32]. Fatigue may be a consequence of alterations or imbalance in sleep/wake mechanisms, but not necessarily so. Sleepiness and fatigue are two interrelated, however distinct phenomena [33]. The circadian and homeostatic processes and their effect on fatigue interact with situational factors, such as hours of service regulations, workload, and light exposure [31]. Staying awake and ignore the homeostatic and circadian-mediated signals for sleep, it is not without consequences [34]. Compared to individuals who are well-rested, people who are sleep deprived think and move more slowly, and make more mistakes [35]. In most occupational settings, a primary reason for fatigue is incompatible timing of duty schedules relative to circadian rhythm and need for sleep. The timing and duration of duty hours play a critical role [31]. None of the participants in the present study worked into the night hours. The health care workers' shifts started between 7 and 8 AM, and ended between 9 and 10 PM. Among the airline personnel, the earliest check-in time was 5:45 AM and the latest check-out time was around midnight. This would limit the degree of sleepiness, as the time of the day is a major contributor of this outcome variable. Individual differences in both tolerance for and impairment from extended work hours have been documented, and is assumed to have a biological basis in trait like, differential vulnerability to fatigue from sleep loss and circadian misalignment [36, 37].

5.5.2 Fatigue

Several research studies have shown associations between extended workhours and outcomes such as fatigue, errors, and workplace accidents [38-42]. Functional impairment related to fatigue is recognized as a significant safety risk in aviation[43]. Fatigue is ultimately a subjective experience, and the measurement of fatigue are essentially subjective[33]. Some definitions of fatigue have attempted to define it in terms of its source, while others have viewed it from a behavioral perspective, treating fatigue as an impairment in performance. Shen et al.'s definition includes both source, behavior and subjective experience: "An overwhelming sense of tiredness, lack of energy, and a feeling of exhaustion, associated with impaired physical and /or cognitive functioning" [33]. Another definitions including both aspects is the International Civil Aviation Organization (ICAO)'s definition: "A physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety-related duties" [44]. Work-related fatigue may be experienced during and at the end of the workday [45], and can occur when there is inadequate time to rest and recover from a work period. Another approach to the definition of fatigue distinguishes between acute and chronic fatigue. Acute fatigue is perceived as a normal protective function of the body, with a rapid onset, and of short duration [33]. Cumulative or chronic fatigue occurs when there is insufficient recovery from acute fatigue over time [12]. As shown, fatigue differs from sleepiness, however sleepiness and fatigue may, but need not be present at the same time, and they may effect work performance and risk of accidents similarly [46]. Balkin & Wesensten proposed differences and similarities between sleepiness and fatigue, and summarized it table 1.1 [47]:

Table 1.1 Conceptual differences and similarities between sleepiness and fatigue

Concept	**Fatigue**	**Sleepiness**
Antecedents	Work (a product of time on task and task difficulty)	Sleep loss, circadian rhythm, and time since awakening
Objective difficulty performing tasks	Yes	Yes
Subjective difficulty performing tasks	Yes	Yes
Reversed by	Rest	Sleep

Safety challenges with regard to the working hours and fatigue have been recognized in the transport sector since the 1930s [12]. It is documented that consequences of fatigue may and do lead to errors and accidents in aviation [48]. However, as accidents are rare and ostensibly random, it has been difficult to predict fatigue-induced accidents despite increasing knowledge of processes underlying fatigue [49].

In the aviation industry, Fatigue Risk Management Systems (FRMS) are implemented, to monitor and counteract fatigue. The good systems are scientifically based, and represent flexible alternatives to rigid work time limitations. They aim at minimizing the adverse effects of fatigue on workforce alertness and performance and the safety risks that these represent [12]. The necessity of fatigue management strategies is also discussed among healthcare workers [50, 51] [52], as fatigue may endanger patient safety [39]. The British Medical Association recently urged the government and other national bodies to develop a comprehensive fatigue management approach for physicians, based on scientific knowledge [53]. If the extended shifts and compressed work periods among the participants in the current study are risk factors for fatigue and fatigue-related errors, it is important to identify potential sleep deficits among the participants, and to be able to distinguish between acute and chronic fatigue by examining recovery among the participants. Studies have shown that the type of tasks involved in the work, as well as individual differences in vulnerability to sleep loss, including trait-like differences and age-related changes are all factors that influences the development of fatigue [54].

It is difficult to discern a relationship between fatigue and accidents or incidents. Neurobehavioral tests may measure task inattentiveness. If the same pattern of cognitive functioning could apply during a given job task, then the observed reaction time (RT) would indicate the interval of inattentiveness during the task at hand. If the demands for cognitive processing is high during such an interval of inattentiveness, human error could occur. For a relationship to occur between fatigue and accidents, a period of inattention, high cognitive demands and a significant impact of error are required to line up temporally in order for fatigue related impairment to actually result in an accident [49].

Therefore, we may only be able to study potential fatigue as measured by subjective ratings, and fatigue-related impairment as measured by neurobehavioral tests, with the inherent limitations of both methods, as only one prerequisite for an adverse event to happen.

5.5.3 The concept of masking

Subjective measures of sleepiness and alertness are vulnerable to numerous confounding factors that can mask their rhythmicity. Because the concept of masking is relevant when studying sleepiness, fatigue, and HRV [55, 56], it is important to clarify what factors and conditions may mask these variables. The context in which such measurements are taken, e.g. environmental or experimental conditions may represent masking factors. Examples of such factors are environmental stimuli and noise, boredom and motivational factors, stress, food intake, posture and activity, ambient temperature, lighting conditions, and stimulant intake, e.g. caffeine. Objective measures of fatigue may also be affected by masking; the practice effect of repeated neurobehavioral tests may mask an otherwise impaired performance [57].

The circadian drive for wakefulness and sleep, and both endogenous and exogenous masking factors may affect neurobehavioral functioning, as well as individual differences and genetics underlying such differences. These masking effects should be considered when neurobehavioral functioning is evaluated [57]. HRV are influenced by circadian rhythms [58, 59], HR [60] , age [61], sex [61], BMI [62], posture [63] , physical activity [55], coffee-intake [64], and smoking[65]. These factors should also be considered, and controlled for to the extent possible.

5.5.4 Cardiovascular strain

The word strain or stress refers to experiences that are challenging emotionally and physiologically. When the human nervous system perceives a stressor, this will evoke responses in several bodily functions, including the cardiovascular system [66]. Extended workdays may represent an external stressor causing increased activity in the sympathetic nervous system.
Human stress response has been characterized as a fight-or-flight response, and an essential mechanism in the survival process. The fight-or-flight response is characterized physiologically by a sympathetic nervous system activation that innervates the adrenal medulla, producing hormones that result in the secretion of catecholamines, especially norepinephrine and epinephrine, into the bloodstream[67].

In a paper on protective and damaging effect of stress mediators, Mc Ewen [68] has introduced two concepts to describe these phenomena; *allostasis* and *allostatic load* or overload. The allostatic load refers to long-term effect of the physiologic response to stress. The allostasis represents the ability to achieve stability. Through allostasis, the autonomic nervous systems protect the body by responding to stressful events. The price of this accommodation to stress can be allostatic load, which is the wear and tear that results from chronic “overactivity” or “underactivity” of allostatic systems. The best-studied system of allostasis and allostatic load is the cardiovascular system. Changes in cardiac autonomic function may be due to physical or psychological strain. Prolonged exposure to strain may lead to an allostatic load, which may result in a wear and tear of the autonomic nervous system, and thus represent a possible pathway to cardiovascular disease [68].

There is consistent evidence for an association between job strain and risk of cardiovascular disease [69]. The demand-control model is perhaps the most commonly utilized hypothesis associating psychosocial factors at work with cardiovascular disease. This model classifies jobs based on psychological demands coupled with decision latitude, i.e. control over the work situation. The primary hypothesis is that high psychological demands coupled with low decision latitude increases the risk of cardiovascular disease.

Measurements of heart rate variability (HRV) register the heart beats and the time intervals between heart beats. HRV is considered a reliable reflection of the many physiological factors modulating heart rate (HR). HR is controlled by the sinoatrial node, which is modulated by both the sympathetic and parasympathetic branches of the autonomic nervous system (ANS). Sympathetic activity tends to increase HR and decrease HRV, while parasympathetic activity decreases HR and increases HRV. Different external stressors may cause increased activity in the sympathetic nervous system; reflected in the HR and HRV. Subtle changes in cardiac autonomic function due to psychological or physical job strain may be detected by analyzing HRV measurements [70, 71].

HRV may be considered an objective measure of individual differences in regulated emotional response, particularly as it relates to mental stress. Several studies have revealed that HRV is a sensitive and selective measure of mental stress [72] [73].

Because previous research has shown a correlation between self-reported occupational strenuous factors and indicators of strain measured by HRV [74], we chose to include HRV measurements in addition to self-reported job characteristics, to assess cardiovascular strain in relation to extended workdays and compressed work periods. We do not aim at studying risk of CVD, but indications of cardiovascular strain, which if persisting over time may represent a pathway to CVD.

5.6 Recovery

Recovery may be defined as the period of time that an individual needs to return to a normal or pre-stressor level of functioning following the termination of a stressor [75].

During recovery, the psychophysiological systems that have been deranged during work unwind to and stabilize at a baseline level of activation [76]. Thus, recovery represents a process in which sleepiness and fatigue are reduced and circadian rhythms are restored. However, when working extended shifts, time to recover between two consecutive shifts may be insufficient and lead to an accumulation of sleepiness and fatigue throughout the working period, with a spillover into the subsequent period off work. Another reason for insufficient recovery may be incompatible timing of duty schedules relative to circadian rhythm and need for sleep. The timing and duration of duty hours play a critical role [31].

Leisure time activities are also influencing the recovery process. Social activities and physical exercise may promote the recovery process, while private or work-related worries may sustain sympathetic activity and thereby impede recovery [77].

The need for recovery from work may be defined as the need to recuperate from work induced fatigue experienced after a day at work. The concept involves the intensity of the fatigue, both mentally and physically, as well as the time required to return to a normal level of functioning [78]. Aspects of sleep differ considerably among individuals even when considering a narrow age range[79], and there are also notable individual differences in the vulnerability to sleep loss [80]. Both age and chronotype are thought to influence the tolerance for shift work by impairing a normal sleep-wake cycle [81].

If an individual does not detach from his or her work during non-work time, work-related thoughts continue to drain resources thus increasing the likelihood of emotional exhaustion. Moreover, lack of detachment implies that one returns back to work in a not fully recovered state the next shift [82]. Rest breaks during work are also considered important for the recovery process and a countermeasure to avoid adverse incidents. [83, 84]. In addition to work-related factors and individual characteristics, the actual period of time available to recovery from work is important. It has been shown that sleep is reduced during quick returns, and after night shifts [85]. In the present study, however, time for recovery for all participants is between extended work days, and after a compressed work period.

Accumulation of fatigue due to insufficient recovery over time leads to wear and tear of the human physiological functioning [68].

5.7 The importance of studying work hours and health and safety

From a historical perspective, the regulation of work hours to the 8-hour workday and 40-hour work week was implemented in order to protect the workers' health and safety. In recent times, there is a pressure to expand thee limits in order to meet several other requirements, e.g. patients' need for continuity in care, employees' demand for more consecutive days off duty, and companies' needs in order to face a strong competition. In light of this development, new knowledge is required on potential health and safety aspects of extended daily and weekly work hours, as well as compressed work periods. In short, this was the incentive for the present thesis.

Previous studies of shift work and health have recommended, in addition to objective assessment of workhours, inclusion of variables concerning sleep and fatigue [46], physiological mechanisms [73], both individual and social factors like age, family situation, chronotype, travel time[85], and subjective report on work characteristics, e.g. perceived job-stress [11].

Based on this we have, included subjective ratings of sleep duration and quality, perceived job characteristics, job strain, subjective reports of fatigue, as well as objective measures, such as HRV variables as indicators of cardiovascular strain, and neurobehavioral tests reflecting fatigue.

5. 8 Hypotheses

The main aim of this study was to examine whether long working hours and compressed work periods could be identified as potential risk factors for fatigue-related errors or indicate cardiovascular strain among health care workers, airline pilots and cabin crew members.

Specific hypotheses:

- Exposure to consecutive extended workdays results in increased cardiovascular strain as measured by HRV.
- Recovery is insufficient after an extended workday and after a compressed work week,

- Subjective reports of work place characteristics are associated with changes in HRV.
- Extended workdays influence performance as measured by in neurobehavioral tests.
- Job content influences performance as measured by neurobehavioral tests.
- Insufficient sleep and fatigue influence performance as measured by neurobehavioral tests.

The thesis aims to increase the knowledge of potential adverse effects of extended workdays and compressed works periods for health and safety in the workplace. New findings may increase the understanding of the underlying mechanisms, and may be a useful tool for employers and employees in the process of optimizing work schedules. Our aim is that this study may be beneficial for both health care management and the management in commercial airlines, as well as the labor unions, in their efforts to develop shift schemes that safeguards health and safety for employees, patients and passengers.

6 Material and methods

6.1 Design

In all three papers of this thesis a repeated measures design was applied , based on a short-term follow-up of three occupational groups, on variations in HRV as a marker of cardiovascular strain, and risk of fatigue-related errors as measured by neurobehavioral tests. Data collection also included a questionnaire concerning health status and sleep patterns, and sleep/work diaries during the follow-up period.

6.1.1 Participants in paper I

The participants in paper I were health care workers employed in a nursing home with 46 patients and eight wards. All health care workers were working according to the same compressed work schedule, alternating between four consecutive 14-hour workdays followed by seven days off, three consecutive 14-hour workdays and seven days off. In addition to a 30 min lunchbreak, the health care workers were entitled to a one-hour break, in which they had access to a room where they could lie down to rest. The entire group was eligible for participation in the study. Forty- four health care workers participated in the study, and were monitored during a work period of four consecutive workdays.

Table 6.1. Health care workers included in paper I

Total number of workers with the actual work schedule	51
Excluded due to medication affecting cardiovascular function	2
Excluded due to health problems or personal reasons	5

6.1.2 Participants in papers II and III

The participants in papers II and III were 18 pilots and 41 cabin crew members, employed in a mid-sized European airline, all based in Oslo (table 6.2). Initially, all pilots and cabin crew members living in Norway and operating only on short-haul flights, were invited to register through e-mails from the airline's management and by representative of the research team visiting the crew base.. Subsequently, at the monthly release of new work schedules, schedules of crew members who had registered and which included eligible work periods were selected. An eligible work period should comprise a minimum of 39 workhours during four consecutive days, in which the first day had 10+ workhours. To avoid high travel costs for the researchers, schedules in which the pilots' or cabin crew members' first day of flight duty ended outside Norway were excluded.

Thirty-nine hours was chosen as a minimum for representing a compressed work period. Likewise, a 10+ hours workday was chosen as a workday well exceeding the 7.5-8.0 hour limits for normal workdays in Norway where the participating airline crew members are based. According to their collective agreement, cabin crew members should be scheduled with rest breaks on the ground. The number of breaks and their duration vary depending on the length of the workday. According to Subpart Q in EU-OPS 1.1130, both cabin crew and pilots are entitled to a rest break when the flight duty exceeds 6 hours, in order to ensure the opportunity for a meal and a drink. These rest breaks may occur while airborne, or in the aircraft during ground stops. The pilots' collective agreement allows for most of these breaks to be held in the cockpit, while airborne. According to in EU-OPS Subpart Q, the minimum rest between two days of flight duty is 12 hours if the flight duty starts at home base. If the flight duty starts away from home base, the minimum rest is 10 hours. A minimum weekly rest is 36 hours, including two local nights.

The data collection was considerably more time consuming than initially planned, due to logistic challenges. Furthermore, the recruitment of pilots was postponed for a year due to ongoing collective agreement negotiations including regulation on working hours for this group. Appointments for data collection were scheduled for eligible crew members, who met the researchers for a first baseline tests at the National Institute of Occupational Health, Oslo. Some participants who lived far from Oslo, and arrived at Oslo Airport the evening prior to the work period, had their baseline tests arranged at the hotel where they stayed overnight. In the evening of their first extended workday , the participants were tested at their final destination. After their fourth workday, they were tested at the crew base at Oslo Airport. Most of the second baseline tests took also place at Oslo Airport.

The airline management provided a dedicated room for the test sessions at the crew base. The number of neurobehavioral test sessions on the fourth workday decreased, due to reassignments of crew to other flights, severe delays and irregularities, or due to sick leave among the participants. The number of subjects who fulfilled the test session on a day off after the work period (the second baseline) further decreased, because many participants lived far from the airline's Oslo-base. Sixty of 519 eligible pilots flying short-haul at the time of data collection signed up for participation during the five days recruitment at Oslo Airport's crew-base. During the data collection period, the actual work period was scheduled for 18 of the 60 pilots, and all 18 were included in the study. The corresponding numbers among cabin crew members were 1058 eligible subjects, 101 who signed up for participation, and the final number of participants 41.

Table 6.2. Number of pilots and cabin crew members who completed the different sessions of neurobehavioral tests and HRV- measurements

Neurobehavioral test session number*	**I**	**II**	**III**	**IV**
Number of pilots	18	18	16	2
Number of cabin crew members	41	41	25	12
HRV measurement-number	**HRV1**	**HRV2**	**HRV3**	**HRV4**
Number of pilots	16	18	13	10
Number of cabin crew members	40	38	24	19

- A test session includes the completion of two neurobehavioral tests: The SART- and the AC-test.

6.1.3 Methods

Cardiovascular strain was assessed by HRV measurements, and fatigue by two computer-based neurobehavioral tests and by completion of questionnaires and sleep/work diaries.

For all three groups of participants, we initiated the collection of the first baseline tests, and attached the HRV-sensor in the evening before the four-day work period. HRV was measured continuous through the first workday until the morning of the second workday. Measurements were started again in the morning of the fourth workday, and continued through the night before the first day off. The second baseline data were collected during the second or third day off work after the compressed work period.

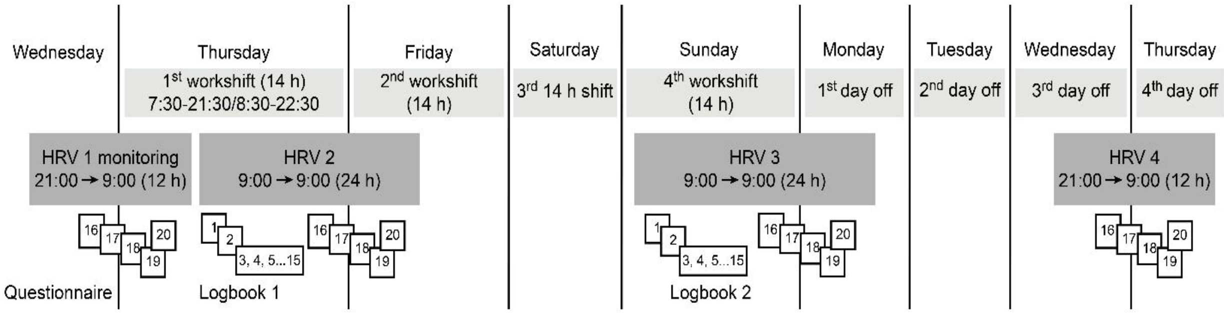
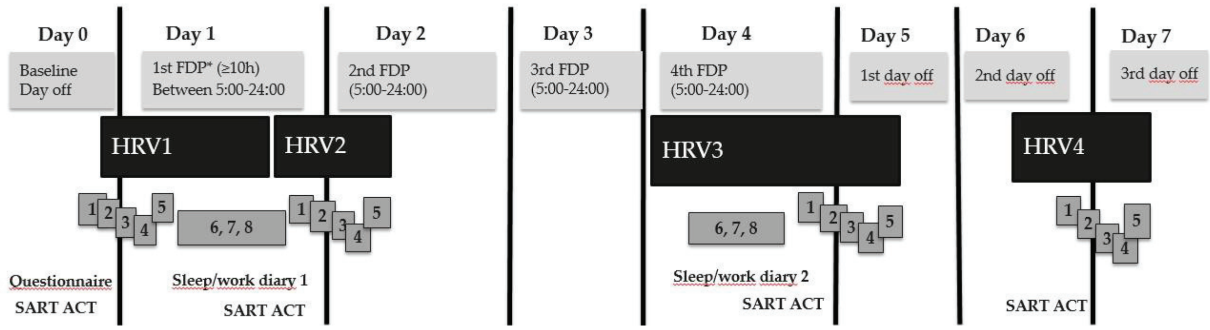


Figure 6.1. Flowchart of the data collection in paper I



*FDP Flight duty period

Figure 6.2. Flowchart of the data collection in paper II and III

6.1.4 HRV measurements

HRV was assessed by three time-domain and one frequency-domain parameters. For assessment of the time-domain parameters, which is regarded as the simplest and most consistent analysis method, we selected the most common parameters; the beat-to-beat interval (RR); the standard deviation of the beat- to- beat intervals (SDNN) which is a measure of overall HRV; and the root mean square of successive differences of the beat-to-beat intervals (RMSSD) a measure of beat-to-beat variability. As to the frequency domain, which expresses HRV as a function of frequency rather than time, we selected the ratio between low frequency and high frequency power

(LF/HF), a ratio considered to reflect sympatho-vagal balance. Low frequency power (LF) (0.05-0.15 Hz) reflects sympathetic activity with vagal modulation. High frequency power (HF) (0.16-0.40 Hz) is synchronous with respiration and reflects parasympathetic activity. High LF may indicate high cardiovascular strain, while high HF indicates low cardiovascular strain. Thus, a high LF/HF ratio is assumed to indicate high cardiovascular strain [86].

The HRV and accelerometer data, which we used for determining the onset of sleep and awakening, were collected by eMotion 3D-sensors produced by Mega Electronics Ltd in Kuopio, Finland. A member of the research team activated the first sensor at the first of the four data collection periods, and provided detailed instructions to the participants on how to apply the sensor, and the importance of removing the sensor when showering, but leaving the pads. The participants applied and activated the sensors the second and third data collection periods. The airline crew members were informed that the mandatory security monitoring before entering airside would not be affected by the sensor.

As indicated in figure 6.1, the sensor (HRV1) used by the health care workers during the first data collection period, was applied on the evening of the first baseline day and removed the following morning (the morning of the first shift), when replaced by a second sensor (HRV2). The HRV 2-sensor was removed the morning of the second shift (24 hours). The third sensor (HRV 3) was applied the morning of the fourth shift, and removed the following morning. Finally, the fourth sensor (HRV4) was applied the evening of the third day off and was removed the following morning.

The airline crew members (figure 6.2) carried the first sensor (HRV 1) from the baseline evening until the evening following the first day of flight duty (24 hours), when a new sensor was applied (HRV 2). This sensor was carried until the morning of the second day of flight duty (12 hours). The third sensor (HRV3), was applied the morning of the fourth day of flight duty, and was removed on the morning of the first day off (24 hours). Finally, the airline crew members were requested to apply the fourth sensor (HRV 4) the evening of the second day off and remove it the following morning (12 hours).

Figure 6.3. Application of the eMotion 3D-sensor

All HRV data were inspected visually to exclude artefacts, e.g. ectopic beats, and was subsequently pre-processed by researchers at the University of Eastern Finland [53] using Kubios HRV analysis software [87].

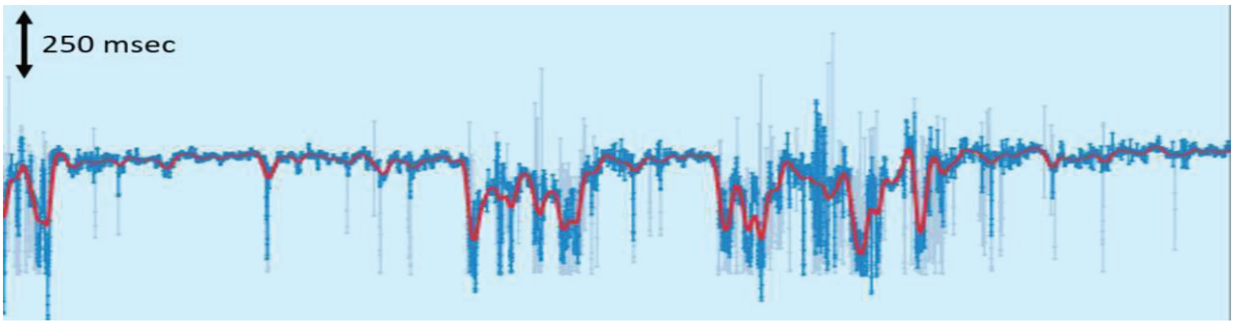


Figure 6.4. Example of low quality RR data 16.40% artefacts in a one-hour segment

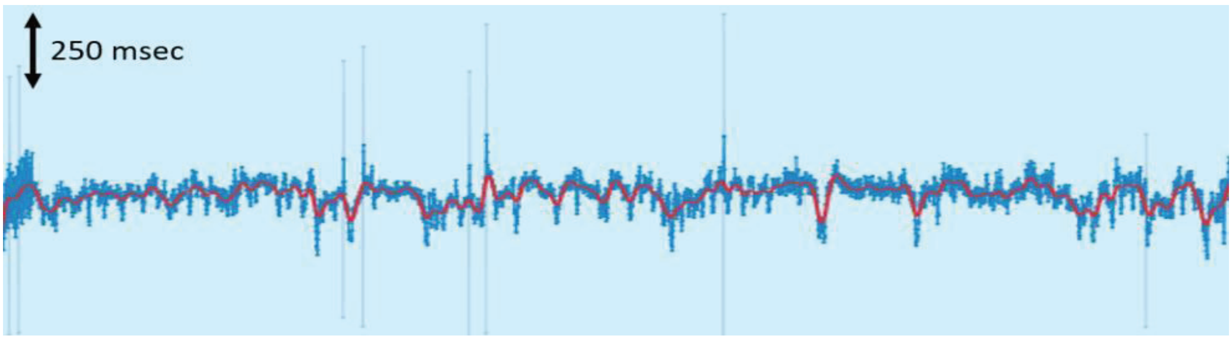


Figure 6.5 Example of good quality RR data 0.59% artefacts in a one-hour segment

For the health care workers in this study, we selected 19 ten-minutes segments from the workday, and five from the night (from the first four hours of sleep and the hour of awakening). For the airline crew members, we selected five-minutes time segments from each working hour during the day, and from the first four hours of sleep, and finally from the hour of awakening in the morning. Hourly mean HRV values were calculated from the selected time segments. A detailed description of this procedure is presented in paper III.

6.1.5 Neurobehavioral tests

Two computer-based neurobehavioral tests were applied, both addressing different aspects of attention and performance, the Attentional Capture Task (ACT) [88], and the Sustained Attention to Response Task (SART) [89]. Participants were instructed about the entire procedure of the test before starting, and the same member of the research team was present at all test session.

The ACT is designed as a combined *complex choice* reaction time test, where the overall task is to press a button as fast and correct as possible when a target stimulus is briefly presented in one of six positions on a screen. It is *complex* in that both the location of the target stimulus in the visual field, as well as location and presence/absence of a task-irrelevant distractor-stimulus, varies. When present, the distractor stimulus (i.e., a red blink) flashes for 60 msec prior to the target appearance equally often at one of six positions at various distances from the target location.

In addition, the AC-test is a *choice* reaction time test in that the target stimulus defines the response mode, so that a vertical or horizontal line in the target stimulus defines which response key the participants should press (the one at his left or at his right hand).

We derived the following variables from the AC-Test-procedures: reaction time (RT), number of correct responses, and precision (number of correct responses/(number of correct responses + number of errors)), in the following four conditions: 1) overall, 2) "cued", with red blinking at target position immediately prior to target presentation, 3) "large distance", with red blink at the three most distant positions, and 4) "short distance", with red blink closest to the target. The test has been described as measuring vulnerability to distractions, described as "attentional capture"[90] assessed by performance during the various distractor conditions. In our study, the test was used as a possible reflection of detrimental effects from fatigue.

We applied a shortened version of the ACT-test, lasting 15 minutes, previously used by Meland et al.[91]. The task is considered a more cognitively challenging than a simple reaction time test, where the task is one simple response to one uniform simple stimulus.

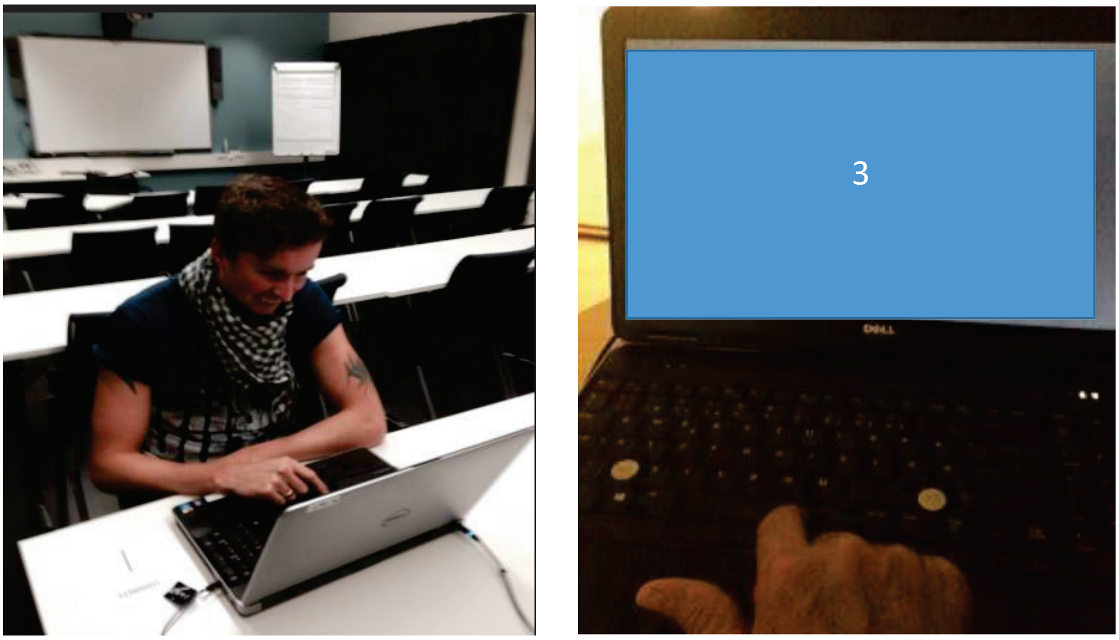


Photo. **Test session SART-procedure (private)**

SART is sensitive to transitory reductions in attention and particularly the response inhibition element of our executive functioning [92]. Inhibition is regarded the hallmark of higher-order control functioning, and the tests reflects sub categories of inhibition important to elite individuals operating in environments characterized by complexity and rapid change [93].

Three scores were derived from the SART: 1) *number of errors of commission* (ie responses to the rare no-go digit), 2) *precision* (ie number of correct responses/(number of correct responses + number of errors of commission)), and 3) *reaction time* to frequent go stimuli > 100 ms. We regarded RT < 100 ms as an anticipation of the next stimulus, thus such responses were omitted from the analysis.

6.1.6 Questionnaires and sleep/work diaries

All three groups of workers were requested to complete a self-administered questionnaire at the baseline meeting, and to keep a sleep/work diary during the first and the fourth workday, both in Norwegian language.

The questionnaires and sleep/work diaries were similar but not identical for the three groups of workers. For airline crew members, questions were included regarding their shift scheme (e.g. fixed or variable), change of crew during a workday, delays, hotel layovers, fatigue- and safety reports. The questionnaire for health care workers included a question on whether there was staffing was in accordance with the shift plan. This is an irrelevant question for airline crew, as the flights will not take off unless the required number of staff, as stated in the EU-OPS, is on board.

The participants rated their level of fatigue according to the Samn-Perelli Fatigue Checklist (SP) [94] included in the sleep/work diary at the start of the workday, after 8 h, and at the end of the workday. The checklist is a seven-point scale with the following categories: 1) fully alert, wide awake; 2) lively, responsive, not at peak; 3) OK, somewhat fresh; 4) a little tired, less than fresh; 5) moderately tired, let-down; 6) very tired, difficulty concentrating; and 7) completely exhausted.

6.1.7 Statistical methods

Variations in the repeated observations of both HRV measurements and neurobehavioral functioning were analyzed using a linear mixed model. The term ‘‘mixed model’’ refers to the inclusion of both fixed effects, which are model components used to define systematic relationships such as overall changes over time; and random effects, which account for variability among subjects around the systematic relationships captured by the fixed effects [95] . Fixed effects model systematic effects of covariates, i.e. age, sex, BMI, and smoking. Random effects model the dependency structure of data. In the present thesis, analyses were adjusted for sex, age, BMI, and smoking and included a random intercept for subjects. The fatigue score from the Samn-Perelli Fatigue Checklist was treated as an ordinal variable.

In paper I and II, we made additional analyses of the effect of HR on HRV by including HR as a covariate in a linear mixed analysis. In the main analysis, we only adjusted for BMI, age and gender by including these as covariates.

We analyzed the HRV-measurements separately for the workday hours, sleep hours and for the awakening hour. Linear mixed models were performed using the lme4 package (version 1.1-12) in R (version 3.3.3) (R-project.org). The scores from the SART- and ACT procedures in paper II were also analysed using this package.

Group differences regarding background information of covariates and effects, were analyzed by Wilcoxon rank-sum test for continuous data, and Fischer's exact test for the categorical or dichotomous data. Specifically, potential differences in age and BMI between registered nurses and nursing assistants were analyzed using the two samples Wilcoxon rank-sum test. We used the Fisher's exact test to assess potential differences between the registered nurses and nursing assistants with respect to reported sleep issues, work characteristics, and physical activity, and between flight commanders and first officers regarding job control and cardiovascular strain.

In all three papers SPSS Statistical Package for Windows 24.0 (SPSS Inc, Chicago, IL, USA), was applied for the analyses of self-reported data from questionnaires and sleep/work diaries.

7 Results / Summary of the papers

The aim of the three papers in this thesis was to assess hypotheses of associations between extended working hours or compressed working time, and fatigue-related errors and indicators of cardiovascular strain, among health care workers and airline crew; cabin crew members and pilots.

7. 1 Paper I

Fluctuations in heart rate variability of health care workers during four consecutive extended work shifts and recovery during rest and sleep.

We chose to use HRV as an indicator of cardiovascular strain, and thus an indirect indicator of risk of cardiovascular disease.

In this study of health care workers we observed reduced HRV, thus cardiovascular strain seems to be higher during the first versus the last of four consecutive extended work shifts. The difference was most notable in the morning hours, but continued for the entire first workday. When comparing the work hour prior to the extra one-hour rest break to the work hour following that break, we did not observe any significant changes of any of the HRV parameters. However, during the break, while most of the participant were lying down to rest we observed indications of lowered cardiovascular strain.

The HRV measurements indicated a decrease in cardiovascular strain in the course of the work period. HRV measurements during nightly observations and subjective reports of alertness in the mornings, support a sufficient recovery after the extended shifts.

We also assessed potential associations between subjective reports of workload, decision latitude, work/life balance, sleep, and fatigue and changes in HRV. We did not observe any such associations. Figure 7.1.A shows LF/HF of subjects reporting of high and low workload, and figure 7.1.B shows the LF/HF of subjects reporting of high and low decision latitude.

LF/HF vs low/high workload

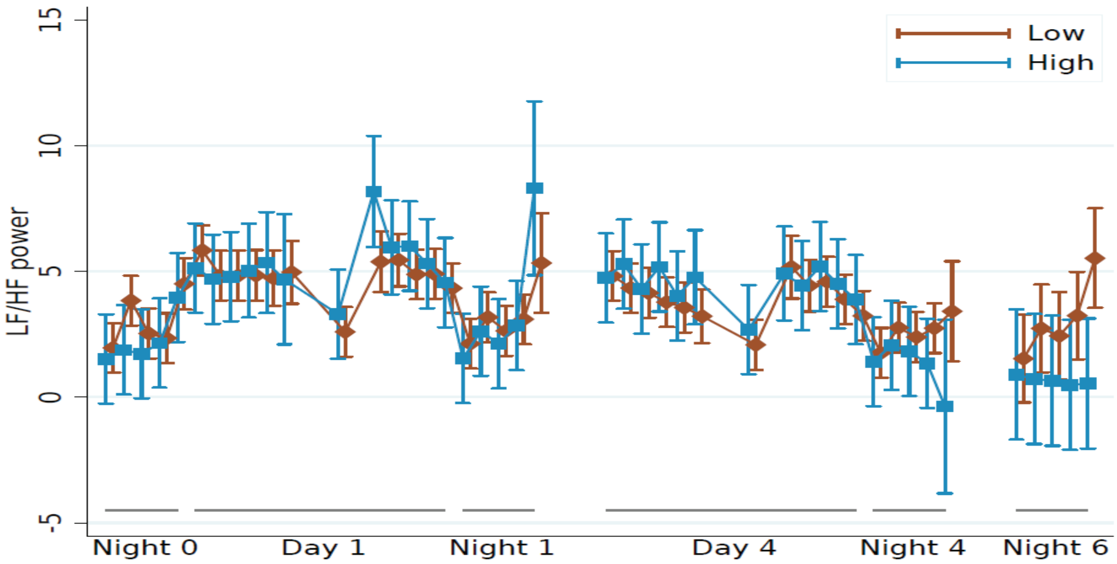


Figure 7.1.A. LF/HF ratio during work and sleep among health care workers reporting high and low workload

LF/HF vs low/high decision latitude

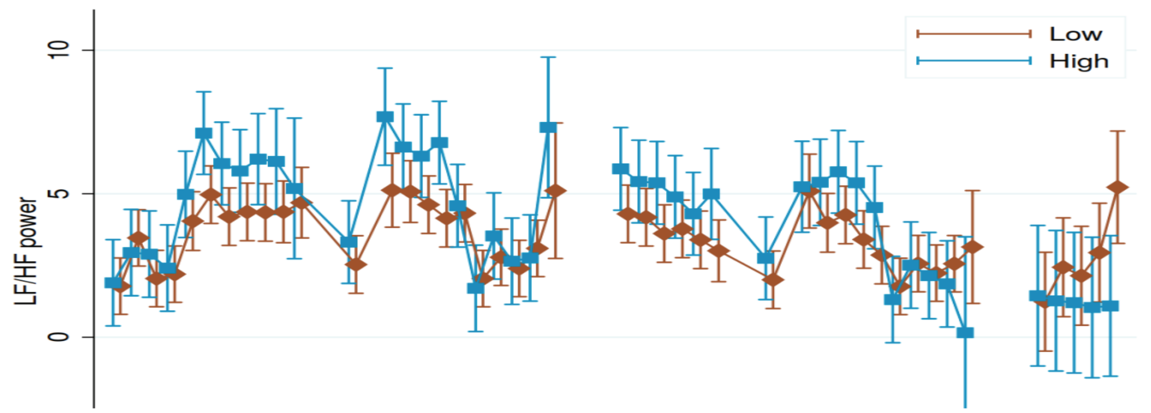


Figure 7.1.B. LF/HR ratio during work and sleep among health care workers reporting low and high decision latitude

Almost all the participants reported of being satisfied with their shift scheme, 75% reported of no work/family conflict, while 21% reported of frequent excessive workload. We did not observe any significant associations between subjective reports and fluctuations in HRV.

According to the work/sleep diaries, the accelerometer measurements, and the Fatigue Check-List responses, the majority of the health care workers seemed to obtain sufficient sleep; mean 5 hours and 48 minutes the night preceding the first and 6 hours and 36 minutes the night preceding the fourth workday. The mean reported sleep duration was 48 minutes shorter the night preceding the first workday than the night preceding the last workday, and the reported sleep quality was improved the night preceding the last workday compared to the night preceding the first workday. We did not observe any associations between reported sleep duration or sleep quality with HRV variables. Despite the observed indicators of elevated cardiovascular strain the first compared to the last workday of the four day-work period of 56 hours, which included an extra one-hour break per day, the results did not indicate any increase of cardiovascular strain in the health care workers.

7.2 Paper II

Risk of fatigue among airline crew during 4 consecutive days of flight duty.

In the second paper, the main objective was to evaluate the hypothesis that single long days of flight duty or compressed four-day work periods increase the risk of fatigue-related errors, as measured by computerized neurobehavioral tests. A second objective was to investigate the hypothesis of an association between subjective reports of sleep duration, sleep quality, and fatigue, and the performance on the selected neurobehavioral tests.

The number of sectors varied from 10 to 20 during the work periods, with a minimum of two sectors and a maximum of 6 per sectors per day. Results from the neurobehavioral tests showed that each additional flight sector included in the work period resulted in significantly longer reaction times both among cabin crew members and pilots.

Overall, no significant increase in the number of errors, decrease in precision, nor any alterations of reaction time were revealed during, or after the work period. No association was observed between performance on neurobehavioral tests and sleep (levels and quality) and rest breaks (number and duration.

A notable practice effect was observed, particularly regarding the ACT as shown in table 7.2.

Table 7.2 Attentional capture task (ACT), overall stimulation, attention and reaction time unadjusted for practice effect

Group	Precision				Reaction time (msec)			
	Test 1	Test 2	Test 3	Test 4	Test 1	Test 2	Test 3	Test 4
Cabin crew	N=39	N=40	N=25	N=9	N=39	N=41	N=25	N=9
	0,5974	0,6491	0,7021	0,7637	804,4	804,4	738,4	693,1
Pilots	N=17	N=17	N=15	N=2	N=17	N=18	N=15	N=2
	0,6057	0,6730	0,7074	0,7302	821,5	807,0	783,0	749,8
Total	N=56	N=57	N=40	N=11	N=56	N=57	N=40	N=11
	0,5999	0,6562	0,741	0,7576	809,6	794,2	755,1	703,4

The execution of the tests became more precise and fast during each test session, even though all participants initially had completed a training session of eight minutes. Younger participants in both professional groups were more precise and faster than the older (Table 7.3).

Table 7.3 Attentional capture task (AC), overall stimulation, attention and reaction time unadjusted and stratified by age for cabin crew members and pilots

	Precision*				Reaction time (msec)			
Age	Test 1	Test 2	Test 3	Test 4	Test 1	Test 2	Test 3	Test 4
<44 years	N=19	N=19	N=12	N=4	N=19	N=19	N=12	N=4
	O,6548	0,7293	0,7837	0,8224)	770,5	742,0	679,9	644,2
≥44 years	N=37	N=38	N=28	N=7	N=37	N=38	N=28	N=7
	0,5718	0,6197	0,6699	0,7205	829,6	820,3	787,3	737,2
Total	N=56	N=57	N=40	N=11	N=56	N=57	N=40	N=11
	0,5999	0,6562	0,7041	0,7576	809,6	794,2	755,1	703,4

***precision:(number of correct responses/(number of correct responses + number of errors))**

The participating pilots' baseline scores on the neurobehavioral tests are slightly better than the cabin crew members' scores. The pilots would have completed neurobehavioral tests in the course of the recruitment process, in addition to their recurrent training, which may explain the baseline differences (however, small) between the participating groups of professionals.

Both pilots and cabin crew members reported of feeling alert in the morning of the workdays, and reported of obtaining sufficient sleep during the four days duty period. They did, however report an increase of fatigue at the end compared to the morning of both the first and the fourth workday. This may indicate that the experienced fatigue could be associated with the work itself or the long workhours, rather than lack of sleep. We did not observe any significant association between reported fatigue levels+ at the end of the first or the fourth workday, and neurobehavioral functioning as measured by the tests.

As a result of the flight schedules, social and family issues may result in fatigue, among workers in aviation workplaces [96]. Forty-four percent of the cabin crew members and 39% of the pilots in the present study reported of difficulties balancing work and private life. Although 29% percent of the cabin crew members and 57% of the pilots reported of perceived high workload, no association was observed, between neither reported workload nor work/life balance and test performance.

7.3 Paper III

***Cardiac autonomic activity in commercial airline crew during an actual flight duty period*.**

The objective of paper III was to assess the association between four consecutive extended workdays and indications of cardiovascular strain, and to assess recovery from the extended workdays, as measured by HRV parameters. A third objective was to assess potential associations between subjective reports of workload, breaks, sleep, and fatigue with respect to changes of HRV parameters.

Among pilots and cabin crew members we observed a trend of decreasing HRV during the work period, which indicates increasing cardiovascular strain. This was most prominent among the cabin crew members. However, in both professional groups, the HRV variables indicated lowered cardiovascular strain all subsequent nights to the night before the first workday.

We found that the changes in HRV-measurements during a 4- day work period of at least 39 hours, indicated increasing cardiovascular strain among both cabin crew members and pilots. Increasing cardiovascular strain was observed on the fourth versus the first day of flight duty among the cabin crew members as indicated by the SDNN and LF/HF-values (figure 2 in paper III), while we observed a significant decreased mean RR during the morning hours of the fourth compared to the first workday.

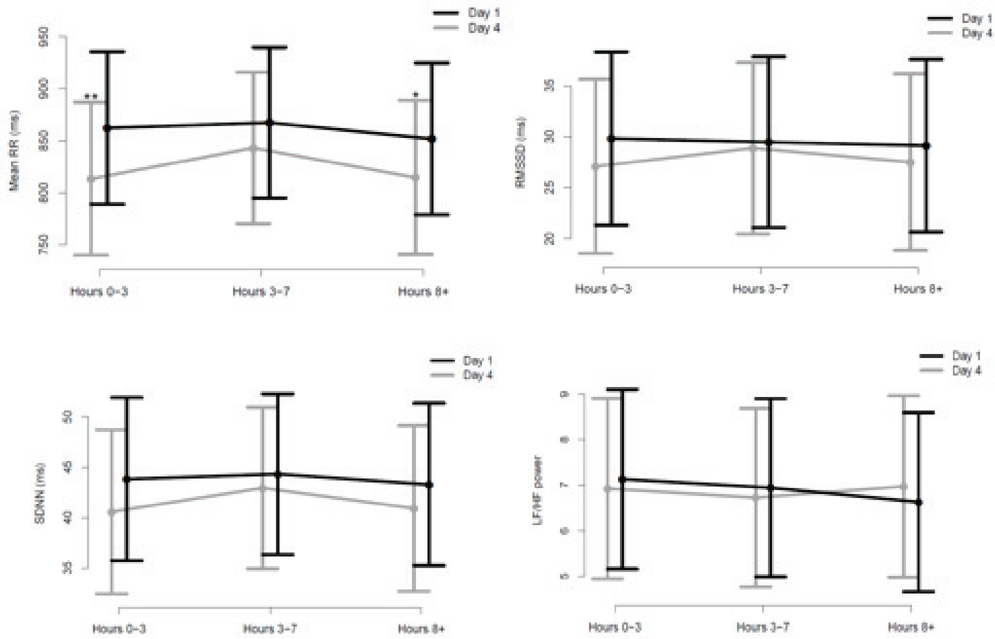


Figure 7.2. Mean RR, RMSSD, SDNN, LF/HF on workday 4 versus workday 1 among pilots

Among the pilots, high demands and low decision latitude were associated with increased cardiovascular strain during the entire work period (Fig. 7.3 A and 7.3 B).

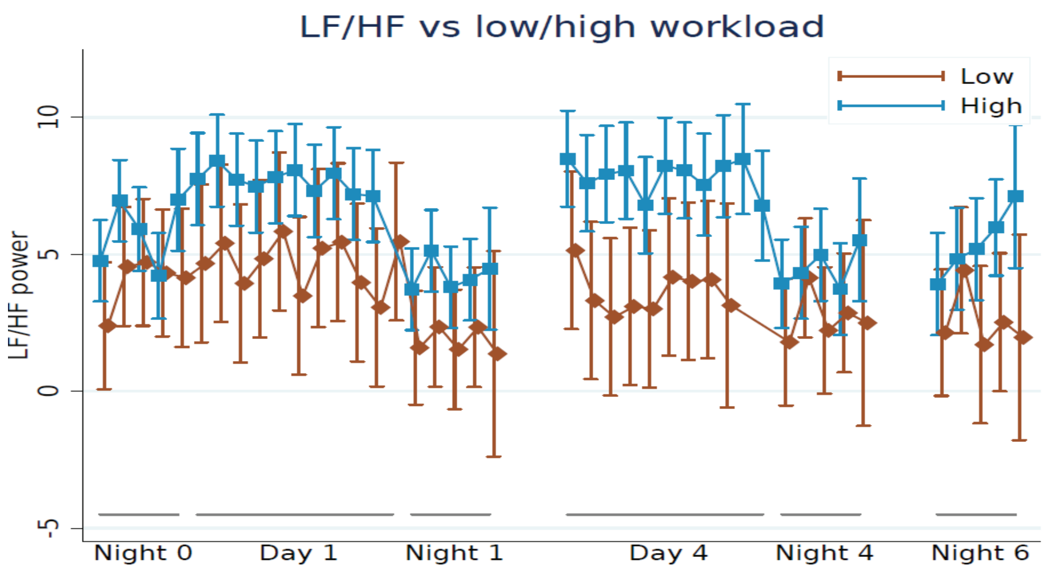


Figure 7.3.A. LF/HF ratio during work and sleep among pilots reporting high and low workload

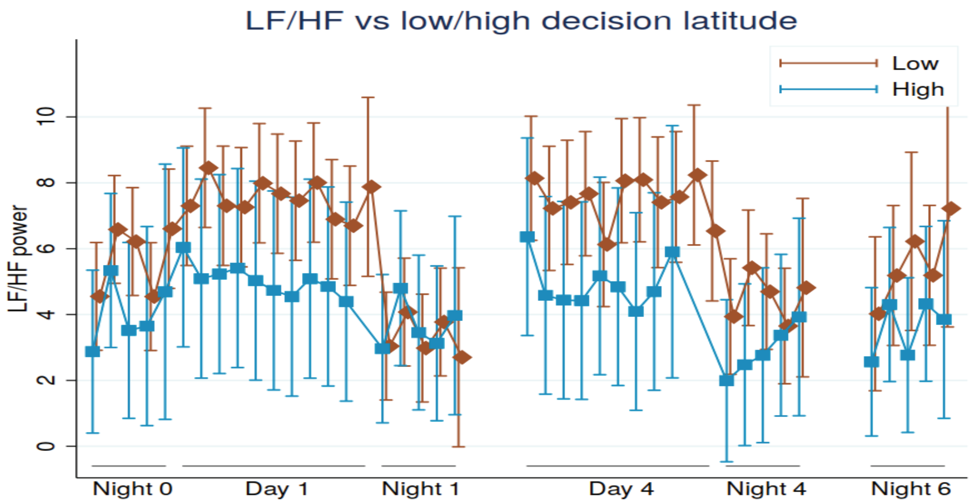


Figure 7.3.B. LF/HR ratio during work and sleep among pilots reporting low and high decision latitude

We observed a different pattern in the cabin crew members (Fig. 7.4 A and 7.4 B), indicating that neither workload nor decision latitude was associated with increased cardiovascular strain during the work period .

LF/HF vs low/high workload

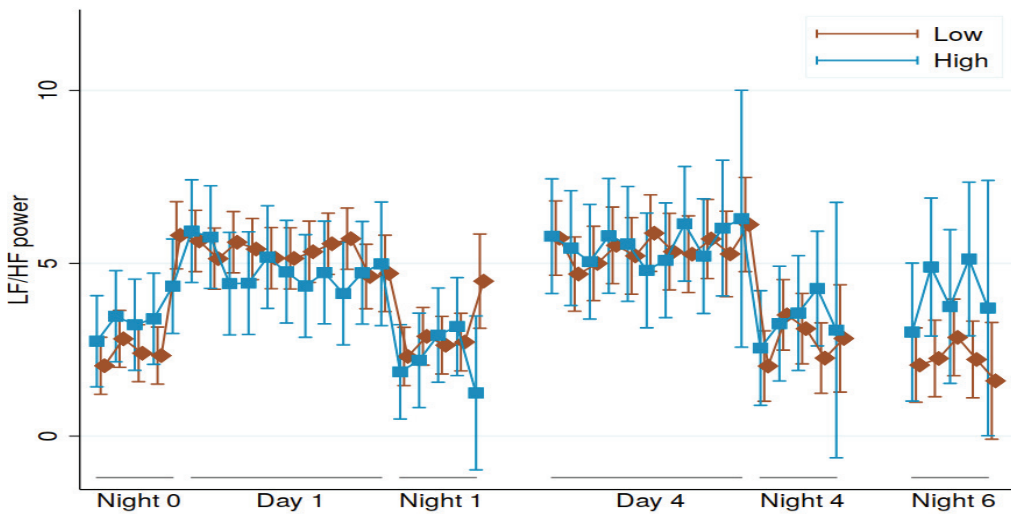


Figure 7.4.A. LF/HF ratio during work and sleep among cabin crew members reporting high and low workload

LF/HF vs low/high decision latitude

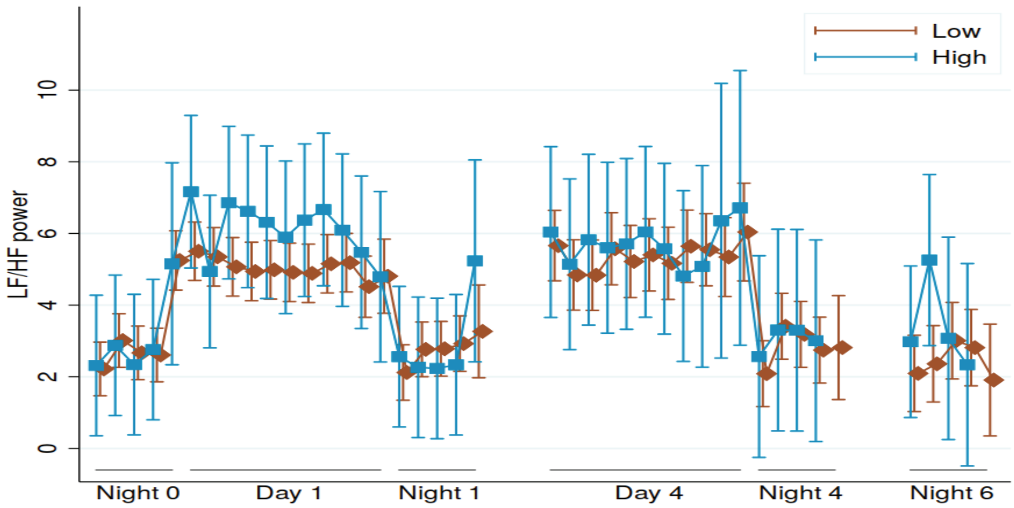


Figure 7.4.B. LF/HF ratio during work and sleep among cabin crew members reporting low and high decision latitude

Among the cabin crew members, increased duration of sleep during the nights preceding the workdays, more breaks and longer total duration of breaks during the workdays, significantly reduced indications of cardiovascular strain.

7.3.1 HRV measurements of all three participating groups

Figure 7.5 visualizes differences in HRV parameters between the three professional groups during the work period and during the second night after the work period. Particularly the measurements of SDNN and RMSSD reveal differences between the health care workers and the airline crew members during the first workday. These parameters indicate higher cardiovascular strain among the health care workers than cabin crew members and pilots during the first workday.

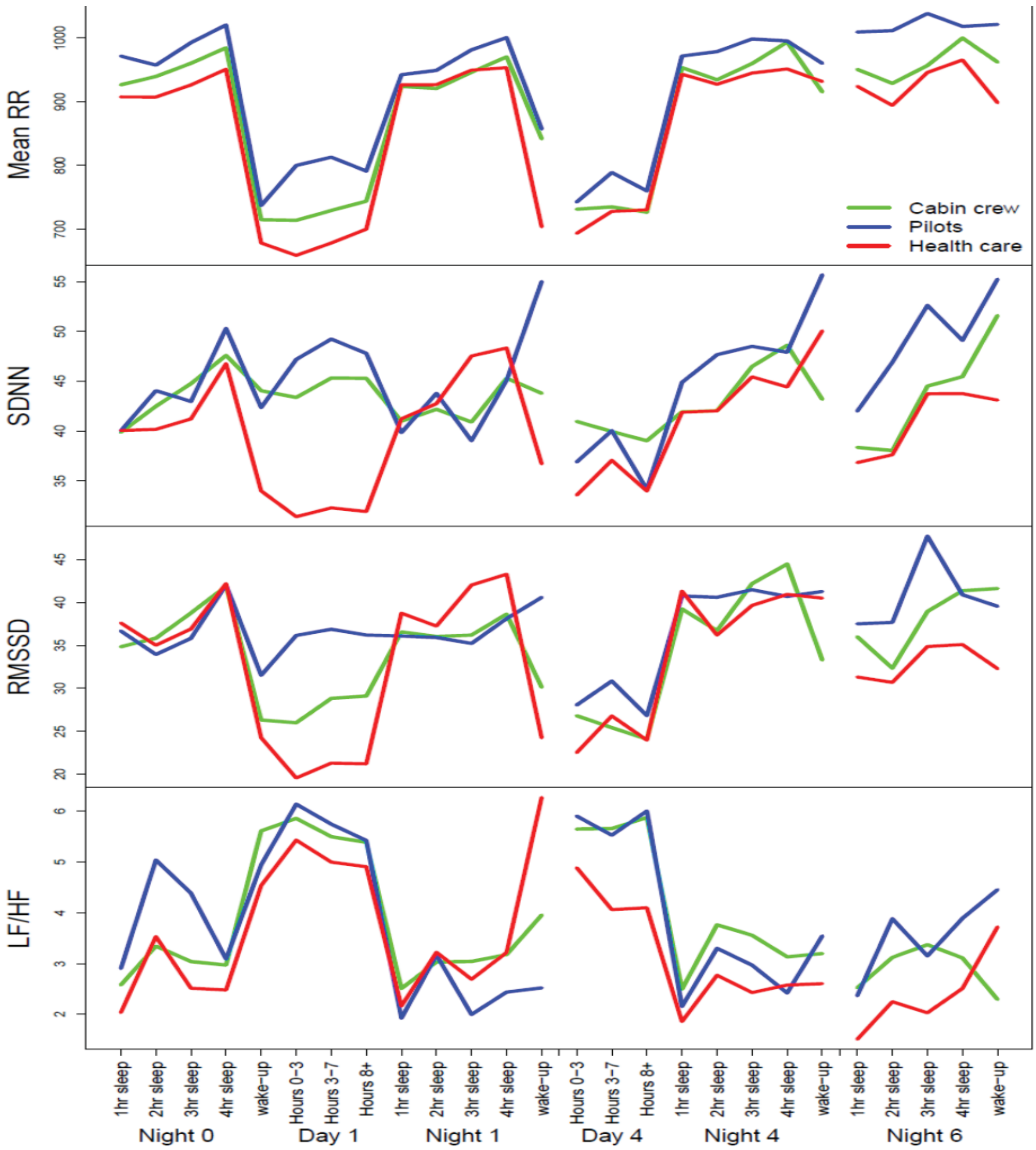


Figure 7.5 Mean RR, SDNN, RMSSD, and LF/HF during work and sleep among health care workers, cabin crew members, and pilots. Adjusted for age, BMI, and sex

8 Discussion of the results

The current study enables a comparison between three different groups of workers with extended daily work hours and compressed work periods, and potential associations with autonomic nervous function as measured by HRV, neurobehavioral function as measured by neurobehavioral tests, and subjective reports of sleep, work characteristics and fatigue.

In the following, the main results of the three papers will be discussed, and to what extent the results responds to the overall aims of the thesis. Furthermore, I will discuss methodological considerations, and finally conclude and mention suggestions for the developers of shift schemes within the industries.

8.1 Cardiovascular strain (Paper I and III)

Taken together, the overall HRV measurements in the three different groups of participants show different profiles. They all show similar diurnal variations, however they differ in the direction of the profiles over the four day period.

In the study of health care workers, we observed indications of higher cardiovascular strain on the first, compared to the fourth workday; the cardiovascular strain decreased during the work period.

A probable interpretation of the highest strain on the first day may be psychological, in terms of an anticipation of high demands before commencing the work period [97]. A study of cortisol at awakening time, revealed higher saliva cortisol concentration on the first workday (Monday) compared to the second day off (Sunday), and there was a significant interaction between job demands or anticipation of work on Monday, relative to Sunday morning [98]. The higher strain on the first day may also have been influenced by factors reducing job confidence, for instance by the lack of shift handovers between two consecutive work teams, and the replacement of most of the patients since the previous work period. The participants reported that they arrived at the nursing home half an hour before the shift started to get updated on the computer, and to prepare themselves for the work period.

A third factor that could have contributed to the apparently higher cardiovascular strain on the first compared to the last workday among health care workers is the shorter sleep duration and more sleep disturbances the night preceding the first compared to the last workday (table 8.1). However, we found no association between sleep duration and cardiovascular strain.

The subjective reports revealed that the work was more strenuous the first day of the work period, as they had to familiarize themselves with new patients, in addition to administer medications for the patients during the work period.

Knauth [26] suggest that extended work shifts may be acceptable if there is satisfactory staffing, proper allowance for rest and recovery, and when physical demands are not too strenuous. We interpreted the decreasing cardiovascular strain during the work period among the health care workers as a result of favorable physical and organizational prerequisites in the actual nursing home. The home was sufficiently staffed, organized in small wards, and may be this contributed to the decrease in cardiovascular strain while they were at work. The workers had the opportunity to leave the ward to lie down in a quiet room during an extra one-hour break. We observed significantly lower mean HR and lower LF/HF during this long break, indicating reduced cardiovascular strain.

Among the airline crew members on the other hand, we observed indications of increasing cardiovascular strain during the work period. While the nurses may have had a higher risk of stress the first work day due to the lack of a handover report, it is worth noting that all scheduled flights in the morning starts with a briefing, or planning meeting, where tasks are distributed among the cabin crew members, so that everyone knows exactly their responsibilities during the flights. Small work teams, labelled "swift starting action teams" are formed during the briefing before every flight, finding common ground, in order to perform effectively from the start [99]. Pilots have a similar briefing meeting, and are also taking part in the cabin crew members' briefing. This may have contributed to the diverse profiles between health care workers and airline crew.

Increased duration of sleep the nights before the workdays was significantly associated with indications of reduced cardiovascular strain among the cabin crew members. Longer duration of rest-breaks during the workdays was also associated with reduced cardiovascular strain. In pilots, sleep duration the night before a work day did not seem to influence HRV parameters, however, we found a significant association between reported high workload and increased cardiovascular strain during the whole work period.

Sleep between shifts is claimed to be essential for recovery [100]. In the present thesis, a majority of the participants from all three groups reported of sufficient sleep duration the nights before the workdays, and of feeling alert when starting their work in the mornings. The HRV- measurements during the nights confirmed this. There were no significant differences in HRV parameters at the time of wake-up between the mornings of the first, second and fourth workday. All three groups of participants reported that they felt alert in the mornings of both the first and the fourth workday. However, the cabin crew members and pilots reported of being significantly more fatigued during a work day compared with the health care worker.
In a recent paper on airline pilots , Charles & Nixon[101] demonstrated that HR increases with increasing task demands, and during multi task conditions. Furthermore, the authors observed variations in HR during different phases of the actual flight, with the highest HR among the pilots during take-off. In the present study, we observed a significantly elevated HR during the morning hours of the fourth workday among the pilots. This may be related to increased strain after three extended workdays combined with the pressure at the time of take-offs. Pilots' reports of high demands, or perceived high workload, were associated with indications of increased cardiovascular strain during the entire work period (figures 7.3.A and 7.3.B) This supports previous suggestions of cardiac assessment as a useful supplement to self-reports, when evaluating flight task mental workload [101, 102].

Because they are being constantly "on the move", cabin crew members have a more physically demanding job than pilots, which could mask HRV. In a previous study, Billman [60] revealed that high physical activity may cause a decrease in HRV even after adjustment for HR. He furthermore claimed that heart rate (HR) may profoundly influence HRV, and should be corrected for in analyses of HRV parameters. In additional analyses of both health care workers and airline crew, we adjusted for HR as an attempt to disentangle the effect of HR on HRV. Although the differences between the first and the fourth workday were reduced, they remained statistically significant for

RMSSD and SDNN at several measured time-points, confirming higher cardiovascular strain the first workday compared to the fourth among the health care workers. We observed a similar pattern in the analyses of the cabin crew members, when adjusting for HR. The differences between day one and day four were reduced, however for SDNN and LF/HF differences remained statistically significant, indicating a higher cardiovascular stain the fourth day compared to the first after adjustment for HR. Adjustment for HR in the analyses of the HRV measurements in the pilots revealed a similar trend as for the cabin crew members.

In experimental settings, exposure to noise has been associated with short-term adverse changes in blood pressure, heart rate, cardiac output, along with increased levels of stress hormones. Noise activates the sympathetic and endocrine systems [103]. The exposure to noise during four consecutive workdays, may have contributed to the observed indications of increase of cardiovascular strain among airline crew members. Both cabin crew members and pilots are constantly exposed to noise, and noise has also been suggested as an intrinsic factor for aviation fatigue [104]. Quite contrary for the workers at the nursing home, where the atmosphere was quiet and peaceful.

In previous studies, a decrease of HRV in elderly, and lower HRV in women has been observed [61, 105]. Consequently we adjusted for age and sex in the analyses. In a study of a large sample of Swiss adults, Felber et al. observed a relation of reduced heart rate variability (HRV) with increased BMI [106]. A similar, inverse association was found between BMI and HRV for all three groups of participants in our study, and adjustment for BMI significantly changed the results. Tobacco smoking is known to influence HRV parameters, particularly within the first 5 to 10 minutes after smoking [65]. Smokers show decreased HRV during day-time compared to non-smokers [107]. We adjusted for smoking in the analyses of health care workers, in which 7 persons were daily smokers. Only one cabin crew member and one pilot were smokers. Because exclusion of the two smokers only caused minor alterations of the results, we kept them in the sample. In a previous study of cabin crew members in the same airline as in our study, Nyberg et al. claimed that the planning of their meal breaks is to a great extent based on flight optimization[108], and this seemed to be the case also among the cabin crew members in our study. We observed that longer duration of rest breaks was associated with indications of reduced cardiovascular strain among cabin crew members. We could not evaluate the impact of breaks among the pilots, because only a limited number of pilots reported of scheduled breaks. Pilots' breaks are most frequently taken in the cockpit while airborne, and on short-haul flights with several flight sectors, one would expect their rest breaks would be kept to a minimum.

8.2 Cognitive function (Paper II)

In paper II, the pilots reported of being less fatigued after the fourth compared to the first workday. The cabin crew members reported of feeling more fatigued at the end of the fourth workday compared to the end of the first workday, which corresponds to the observation of a larger reduction of HRV observed for this group on the fourth workday.

A study of nurses, by Han et al. revealed that work schedules including extended shifts may lead to fatigue, and that psychological job demands are significantly related to fatigue and insufficient recovery [109]. In the aviation industry, pilot fatigue represents a significant challenge, and may be a result of unpredictable working hours, extended duty periods, circadian disruption, and insufficient sleep [5, 48]. Studies of cabin crew members show that their extended and irregular working hours have a negative impact on sleep and performance, both critical aspects for both safety and security in flight operations [110]. In the present study however, the majority of both pilots and cabin crew members reported of sufficient sleep during the work period, and the overall results from the neurobehavioral tests revealed no negative changes, neither with respect to precision nor reaction time. However, RT increased among both cabin crew members and pilots by each additional flight sector during the work period.

The risk of making mistakes and thus of occupational accidents are higher during extended work shifts due to the longer exposure time [111]. Folkard et al. [4] revealed that 10-hour shifts were associated with a 13% increase in risk of occupational accidents when compared with eight hour shifts, and 12-hour shifts with a 27% risk elevation. Tests designed to assess neurobehavioral function may, however, not be representative for occupational duties in a real- life scenario. Van Dongen and Hursh have illustrated the relationship between fatigue and potential accidents by viewing series of increased reaction times using PVT as task inattentiveness [49]. According to their findings, if the increase of reaction times we observed among pilots had appeared during real life work tasks where cognitive demands were high, the risk of human error would be present. These authors claim that if the impact of human error at that specific time is high, then an accident could take place. In order for fatigue-induced impairment to actually result in an accident it is necessary with a period of inattentiveness, high cognitive demands, and significant impact of error to all line up temporally [49]. The pilots' procedure oriented work program, in which each task is controlled by the reading of checklists by a co-pilot, probably reduces the risk of errors. Reaction time will however, not benefit from the use of such checklists.

Previous research has revealed that the number of flight sectors makes an important impact on pilot fatigue [112, 113]. In the current study, the neurobehavioral tests of airline crew showed longer reaction times, with each additional flight sector included in the work period.

When evaluating the performance of both the applied neurobehavioral tests, we observed what is probably a trade-off between accuracy and speed. Previous research suggests that young adults attempt to balance speed and accuracy to achieve the most correct answers per unit time, whereas older adults attempt to minimize errors even if they must respond slower to do so [114]. Thus, the analyses were adjusted for age. Among the cabin crew members, reaction time increased with age, however, the number of errors decreased.

We did not examine the association between the number of flight sectors with check-in times for duty during the work period. The increased RT by increasing number of flight sectors should be considered within this limitation, as early check-in is known as a contributing factor in the development of fatigue [112].

8.3 Subjective reports

The scores of the Samn-Perelli Fatigue Check List (figure 8.1), differ notably between airline crew and health care workers. The scoring of fatigue is higher among airline crew during the whole work period. The check List includes the following categories: 1) fully alert, wide awake; 2) lively, responsive, not at peak; 3) OK, somewhat fresh; 4) a little tired, less than fresh; 5) moderately tired, let-down; 6) very tired, difficulty concentrating; and 7) completely exhausted.

The mean scores showed that all three groups felt more alert in the morning of the first workday compared to the fourth, even if the reported quality of sleep were worse and sleep duration was shorter the night preceding the first workday .

The pilots (flight deck) reported a slightly lower degree of fatigue at the end of the fourth compared to the first workday. Possible explanations include the slightly shorter mean working hours on the fourth day in this group, and the fact that they did not have to commute on the fourth day. The cabin crew members reported of being more fatigued at the end of the fourth day, which corresponds to the observed reduction in HRV on this day. The health care workers reported of only minor differences in experienced fatigue between the two workdays (Fig. 8.1).

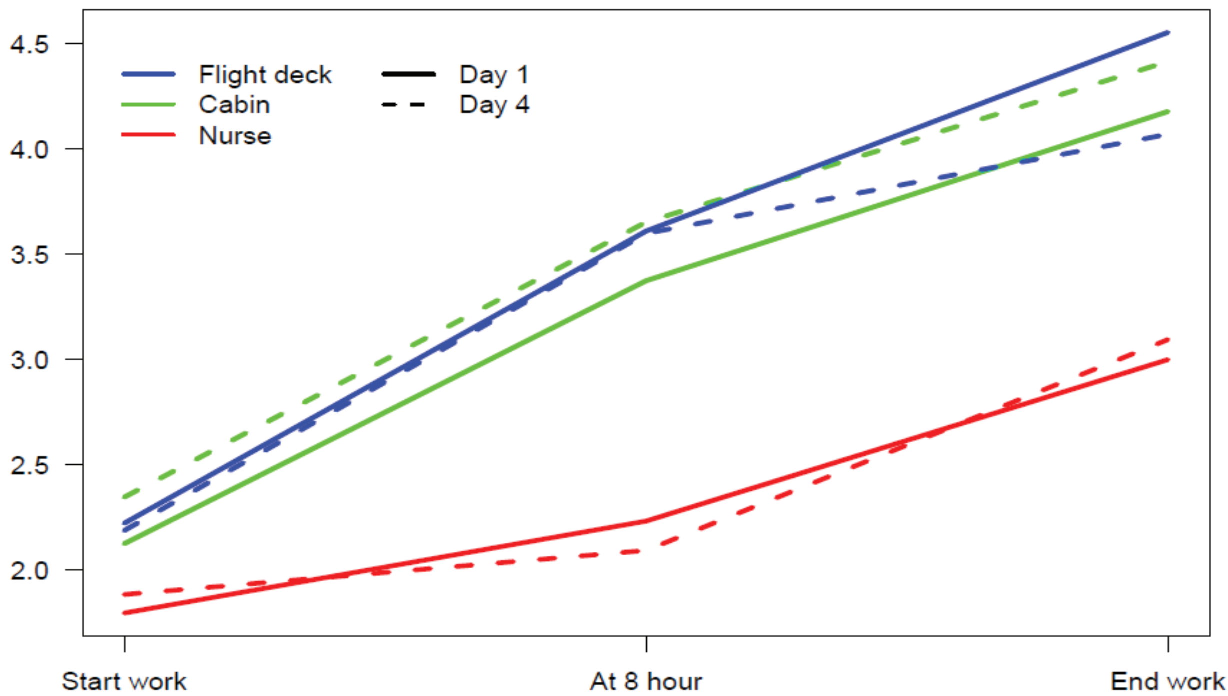


Figure 8.1 Mean scores on the Samn-Perelli Fatigue Check List during workday 1 and 4 among all three groups of participants

Lack of sleep is considered a major factor when assessing fatigue [96]. A study of van Dongen et al. showed that restriction of sleep to six hours or less per night over time, resulted in cognitive performance deficits equivalent to up to two nights of total sleep deprivation [115].

In the present work, the reported mean duration of sleep among health care workers, cabin crew members and pilots did not indicate any severe sleep deficits (Table 8.1). However, sleep duration was somewhat shorter the night preceding the first compared to the fourth workday. Reported sleep patterns also revealed an increase in sleep quality from the night preceding the first compared to the night preceding the forth workday. Thus curtailed sleep is not expected to be a major contributor to performance deficits in our study, which is also largely in line with our observations of test performance during the work periods.

Table 8.1 Reported duration of sleep and sleep patterns the nights before workday 1 and 4, among health care workers, cabin crewmembers, and pilots

	Mean duration of sleep (range)	≥ 30min before falling asleep n (percent)	≥ 30min before falling asleep n (percent)	Awakening ≥ 30min before planned n (percent)
Health care workers				
Night before Day 1 (n=24)	5h 48min (3-7h 30min)	10 (44%)	8 (35%)	9 (38%)
Night before Day 4 (n=24)	6h 36min(5-8h)	8 (33%)	4 (17%)	4 (17%)
Cabin crew				
Night before Day 1 (n=41)	5h 56min (4-8h)	16 (39%)	13 (32%)	16 (39%)
Night before Day 4 (n=26)	6h 47min (4-8h)	4 (10%)	7 (17%)	14 (34%)
Pilots				
Night before Day 1 (n=18)	6h 18min (4h 30min-8h)	5 (28%)	3 (17%)	5 (28%)
Night before Day 4 (n=16)	7h (4h 30min-10h)	1 (6%)	3 (17%)	4 (22%)

Our studies of airline crew members, include only short-haul operations. However, as cabin crew members operate both short- and long-haul flights, reported increased tiredness in this group at the end of the work period could be a spill-over effect from previous work periods of long-haul operations.

In a recent study by Lee & Kim [96], pilots reported of the following major items increasing fatigue: crew scheduling, different flight directions, inadequate aircraft environment, inappropriate job assignments, and poor hotel environment. Regarding the relation between work schedules and fatigue, Jansen et al. [116] claim that certain perceived job characteristics might play an important role in the development of fatigue, e.g. high psychological job demands, decision latitude, and perceived strenuous work. In the current thesis, particularly among the pilots, reported high demands and perceived high workload were associated with HRV parameters indicating cardiovascular strain during the entire work period. Cardiovascular strain has been regarded as a robust indicator of mental workload and pilot performance in previous studies [101, 102], and also in the present study. These findings suggests that such measures are useful additions to self-reported measures.

Although the number of consecutive work days were similar between the studied health care workers and airline crew members, comparisons of the shift schemes and other work characteristics revealed a number of dissimilarities.

The shift schemes of the health care workers were regular and predictable. Their four-day compressed work period was followed by seven days off. They worked in small and stable teams of co-workers, with responsibility for relatively few patients. Rest-breaks were long and regular. The mean one-way commuting time was only 15 minutes. Almost all participants reported of being satisfied with the shift scheme, which they had actively chosen.

A different situation was found among the airline crew members. They had maximum three days off both before and after a four day work period, and their shift schemes were irregular and unpredictable. The mean one-way commuting time for the cabin crew members was approximately 60 minutes, and for the pilots 70 minutes. Rest breaks were short, and unpredictable regarding timing and duration, and often held in the galley area while airborne. The pilots' rest breaks were not scheduled, and were held in the cockpit while airborne

Similar to cabin crew members, pilots are exposed to vibrations [117], low air humidity [118], air pollution [119], and noise [120], all factors that may have contributed to the observed indications of increased cardiovascular strain and reported increase of fatigue during the four-day work period.

While the average duration of employment among the participating health care workers was less than two years, the airline crew members had long average employment time in the airline. The shift schemes of the airline crew members went through slight changes due to negotiations every 2nd year until around 2012, when work hours increased substantially, and later negotiations have not reverted this.

The independent variables of this study were different for the three participating groups regarding shift length, shift timing, total hours worked, roster pattern and break duration and frequency. The mediating variables were also different with respect to work content, work intensity, commuting time, age and gender of the workers, gender, work/life balance etc.

In light of this, shift schemes or systems may be conceptualized as a complex ecology of interdependent factors rather than a set of dimensions considered in isolation [121].

9 Methodological considerations

In general, the results from a research study are influenced by the selection of the study population, the way the study is conducted, the applied study methods, and the context in which the study takes place.

In this thesis, the three papers include multiple outcomes, not necessarily independent of each other, that are tested for significance. Thus, the significance of single outcomes should be interpreted with some care, and focus should rather be on overall trends, and on robust significant findings.

In the following, we discuss the applied study design, selection of the study population, and the potential sources of systematic errors, such as selection bias, information bias, and confounding.

9.1 Study design

The chosen study design in all three papers is observational, with repeated measurements.

A cross-shift, cross-week design was applied, which in some aspects resembles a prospective design, and in other aspects resembles a cross sectional design. We followed the participants from a first baseline, through four workdays, to a second baseline after a period of two or three days off work, an advantage compared to a strict cross- sectional design in which observations are made at one time-point only. Other advantages of the chosen design is that clear cut definitions may be applied to the exposure [122], and that there is no confounding from an external control group [123]. However, the chosen design cannot support any causal relationships.

We applied linear mixed models for the main statistical analyses. Such models are powerful and flexible analytic tools for this kind of studies, in which subjects are measured repeatedly over time or under different conditions. This approach does not assume that observations are independent, a major assumption behind traditional regression models. Repeated measurements on the same individuals using traditional regression models may lead us to believe that our data gives us more information than what they actually do, which may lead to an underestimation of standard errors[122, 124]. Linear mixed models include fixed and random effects. Fixed effects model systematic effects of covariates, i.e. age, sex, and BMI, and random effects model the dependency structure of data [125].

Loss to follow-up is a challenge within this design. And in the present study this was more pronounced among airline employees than among the health care workers, due to delays and frequent reassignments.

While a clear cut definition of the concept fatigue is not straightforward in this study, the exposure has been easy to define.

9.2 Selection of participants

The participants of this study were recruited on the basis of their shift scheme; four consecutive extended workdays, including 56 working hours for all the health care workers and 39-42 hours for the airline crew.

All 51 health care workers in the studied nursing home who had actively chosen a shift scheme including four consecutive 14-hours workdays, were invited to participate in the study. The participation rate was high. Two workers taking medication that affects cardiovascular function were excluded. Another five workers did not want to participate due to health or other private reasons private reasons, such as long commuting time. The rest of the workers contributed to all, or some of the tests, as a result we consider the risk of selection bias to be small.

Of the six participants who terminated their work at the nursing home during the time of the data collection, only one stated the shift scheme as a reason. The other five all held temporary positions at the home, and terminated their employment when they were offered permanent positions elsewhere. These participants quit their positions for other reasons than the purpose of the study.

If done with utmost care, the results may be generalized to nursing homes with similar shift schemes and resources.

When selecting airline crew members for the study, we used a two-step procedure. In the first step, we invited all pilots and cabin crew members living in Norway and operating short-haul flights to register. In step two, every month when all the new work schedules were presented, a selection was made of those among the registered subjects who were assigned to a four-day working period of minimum 39 hours, in which the first day was at least 10 hours.

Participation in the study required that the participants agreed to be available on their time off, both on the evening prior to the work period, after the first and last day of flight duty, and on a following day off. As to step one, it is not unreasonable to assume that airline crew members who found their job situation very fatiguing, individuals experiencing challenges regarding work/life balance would not wish to participate. On the other hand, tired employees could have been eager to participate in order to document the burden. However, mean age, gender distribution, and mean duration of employment of the volunteers was equivalent to those of all cabin crew and pilots operating the actual aircraft, This suggests that there was no serious selection bias in step one. As to step two, according to the airline, the assignment of the actual work schedules was made randomly, thus reducing the risk of selection bias.

Delayed flights, sick leave, and rescheduling of crew caused incomplete sets of neurobehavioral tests.

Traditional linear regression models exclude participants with missing values, and accordingly do not utilize all collected data in the analyses. Contrary to this, when using linear mixed models, all observations may be exploited. Removing individuals with non-complete observations results in less power. This gives also potentially more biased estimates as it is less robust to the missing data mechanism [126, 127]. Linear mixed models gives unbiased estimates if data are missing at random, and are more robust than traditional linear regression models where data must be missing completely at random. When data are not missing at random, the estimates may be biased, however the estimates from a mixed model will generally be more robust and less biased than by using traditional regression models [126].

9.2.1 Sample size

We planned to include 40 participants in each study group to allow for sufficient statistical power. The number of cabin crew members decreased due to loss to follow up for various reasons mentioned above. The pilot group ended up as small due to practical reasons. The collection of data in participant number 18 took place in the autumn just before the company introduced the winter program, which did not include work periods that fulfilled our criteria. To wait another six months until the next summer program would be introduced to continue the data collection was not practical feasible.

The small sample size, particularly the limited number of participating pilots raises the question if the study has sufficient power to examine the effects of the various factors of cardiovascular strain and fatigue. This could lead to an increased probability of type II error, i.e. not rejecting a null hypothesis that is false [122]. Due to the small sample size in the current study, the results should be interpreted with caution. The studied shift schemes does not produce a big variance in particularly the neurobehavioral functioning, and may thus limit the possibility to run regression analyses. However, even if the shift schemes should not produce much of a perturbation in neurobehavioral and/or cardiovascular function, the analyses stratified by e.g. work load, work content (number of flight sectors), and decision latitude, demonstrated contrasts valuable for the testing of hypotheses.

9.2.2 Motivations for participation

Orne [128] points out several important characteristics involved in a test situation that may influence results. He assumes that motivation of an individual to participate in a study may be an identification of the aim of the study, and thereby the individual has a stake in the outcome.

The participants from the different professional groups could have very different motivations for participations, which could have influenced the results: The shift scheme in the nursing home represented an exemption from the National Working Environment Act with respect to number of daily work hours. However, the majority of the health care workers were happy with their compressed work periods, and hoped that the result of the study would reveal no negative effects. Not all the participating airline crew members were happy with their shift scheme, and many experienced their workload as strenuous, and that the shift scheme affected the work/private life balance in a negative way. Unlike the health care workers, they had not chosen the shift scheme, and their workhours had increased due to the company's difficult financial situation.

Which motivation a participant most likely has, and which factors that may affect his/her reaction to the test stimuli. Individuals taking part in a study would most probably be concerned with the usefulness of their performance. They would want to validate the hypotheses.

Motivational factors may also influence employees' evaluation of the workplace [129]. The health care workers of the present study, had all chosen to work the 14-hours shift scheme, and expressed satisfaction with this shift scheme. This finding is in agreement with a previous study of nurses alternating between 8 and 12-hour shifts. The 12-hour shifts were preferred, as such shifts resulted in fewer workdays, and greater flexibility regarding leisure time activities [130]. Few of the health care workers reported of a high workload or a poor work-life balance.

The airline crew members have little or no influence over their shift schemes. However, before applying for a job in the airline, they knew about the extended shifts and the irregularity of the shift schemes. We might assume that there is both a healthy hire and a healthy worker effect [131] among these employees. Those who have suffered from severe sleep problems and social and family issues have probably left the job in aviation. However, they may still have been more prone to report for instance work/private life balance issues, which was also reflected in the self-reported responses to questions regarding this.

9.2.3 Selection bias and generalizability

Selection bias is a type of systematic error that can arise from the procedures by which the study participants are selected [132], and occurs when the association between exposure and endpoints differs for those who participate and those who do not participate in the study [133].

The high mean age of particularly the pilots in our study group, may not be representative for all commercial airline pilots and cabin crew members flying short- and medium haul operations in European airlines. Varying flight time limitations, and working conditions regulated in collective agreements, in addition to operating varying aircraft types, flight routes, and passenger load factors in different commercial airlines, weaken generalizability to a broader group of such workers. A generalization to the general working population, would have been hampered by both a healthy hire- and a healthy worker effect [134]. Strict health criteria are followed when recruiting pilots and cabin crew members, resulting in a hired group that is healthier than the general population. Considering the long employment of the participants, it is reasonable to assume that it is the healthiest workers who have remained in the job.

The results for the airline crew members, may possibly be generalized to crew members in mid-sized European airlines who are subject to the same legal regulations of working time.

Only after start-up of the study at the actual nursing home, the extra resources this home had, regarding e.g. staffing and equipment, became apparent, Thus, the external validity or generalizability to the general population of nurses would be considered limited [135].

Our samples are based on non-probability sampling, which limit the generalizability of the results. We used volunteer sampling; which is a type of convenience sampling. The decision to participate relies on respondents based on an invitation that is not individualized [136]. Among airline crew, however, the final sample was made of the volunteers who, during the actual period, were scheduled according to the scheme of interest. Nonetheless, a non-probability sample constitute information that has both utility and value in the description of changes in particular samples [137] , like the ones in this thesis.

9.2.4 Lack of control group

The applied repeated measurement design without a control group, complicates the assessment of accumulated strain during four consecutive extended workdays compared to a standard working week. On the other hand, choosing appropriate control groups also contain inherent challenges and pitfalls. Identifying a relevant control group of health care workers with standard working weeks was not straightforward. Health care workers from another nursing home would have different number and type of patients, different staffing, different standard of the premises, and different economic resources. A control group for the airline pilots and cabin crew members would be impossible to obtain, as no airline crew have standard working hours.

Thus, instead of comparing the results with a control group within the same profession, but with different work-schedules, we chose to compare the potential changes and differences in alertness and cardiovascular functioning in the same workers during a work period, and between two different groups of professionals with similar compressed work periods.

9.3 Information bias

Information bias occurs when measurements or classifications of exposure or outcome in a study is flawed . [122]. Errors in measurement may be introduced by the observer, by the participant or by the instrument (e.g. questionnaire). In this study, however, we have exact knowledge of the exposure variable *working hours*. The shift schemes are recorded in the air company's and nursing home's time registers. However, working hours do not represent all aspects of the total exposure. The intermediate variables like work content, work load, and number and duration of rest breaks are examples of factors that are subjectively reported that may be misclassified. In particular, these intermediate variables may result in some information bias.

9.3.1 HRV parameters (Paper I and III)

We chose to use HRV measurements as indications of cardiovascular strain in this study.
Although there are limitations regarding an assessment of cardiovascular function by HRV, the method was chosen because it is a simple and non-invasive procedure widely assumed to reflect changes in the autonomic regulation, and enabling indirect observations of subtle changes due to strain, stress and recovery [138].

In the time-domain, which is regarded the simplest and most consistent analysis method, we have chosen the most common parameters; the beat-to-beat interval (RR), the standard deviation of the beat- to- beat intervals (SDNN), which is a measure of overall HRV, and the root mean square of successive differences of the beat-to-beat intervals (RMSSD); a measure of beat-to-beat variability.

In the frequency domain, which expresses HRV as a function of frequency rather than time, we have chosen the ratio between low frequency and high frequency (LF/HF), which is believed to reflect sympatho-vagal balance. Low frequency power (LF) (0.05-0.15 Hz) reflecting sympathetic activity with vagal modulation. High frequency power (HF) (0.16-0.40 Hz) is synchronous with respiration and is reflecting parasympathetic activity. High LF may indicate high cardiovascular strain, while high HF indicates low cardiovascular strain. High LF/HF ratio is assumed to indicate high cardiovascular strain. However, this concept has been challenged, in particular the underlying assumptions that sympathetic and parasympathetic is a key contributor to LF, and that sympathetic and parasympathetic activity operates in a reciprocal manner with linear interactions. Despite these controversies, it is an often used measure of a balance, where an increase supposedly indicates a sympathetic dominance and a decrease indicates parasympathetic dominance[139, 140].

There is a marked inter-individual variation between HRV response and different levels of autonomic stimulation. HRV data may be influenced by artefacts from breathing, in addition to being affected by circadian variability. In the present study, all HRV measurements were visually inspected, and artefacts were excluded before selection of time segments. No "gold standard" of HRV exists, but in our study the choice of HRV-parameters and their interpretations are according to the recommendations for best practice by the Task Force of the European Society of Cardiology [141].

Some HRV-measurements were excluded from the analyses due to poor quality of the data. However, a comparison of participants with incomplete datasets and those who had complete datasets, did not reveal any significant statistical differences regarding age, sex, BMI, marital status, number of children under 18 years of age, reported work characteristics, employment duration and physical activity levels.

9.3.2 Neurobehavioral tests (Paper II)

The purpose of the neurobehavioral tests was to reveal alterations in reaction time or precision after an extended workday or compressed work period. Both the SART and the ACT tests were completed on a computer, and as far as possible, under standardized and undisturbed conditions.

As far as possible, we sought to complete the test sessions for one person at the same hour in the evening. Due to some variation in the check-out times for duty, and due to flight delays, this was not always possible, and error variance may have increased influenced by the circadian rhythm. Participants most likely became more tired or sleepy the later the tests was to be completed. The subjects would probably get more tired or even sleepy the later the tests were performed.

Both tests have been used previously in studies of high performance cohorts, and the SART procedure also during a combat scenario among military personnel [91, 142, 143]. SART errors are assumed to be associated with reports of attention failure in everyday life [144]), and the reliability of the SART procedure has been tested in a previous study where subjects were tested on two occasions over a period of one week, showing that the performance on the test was stable over time [92]. Contrary to criticism, it has been demonstrated that SART errors are associated with reports of attentional failures in everyday life. An important claim of the SART is that it is significantly related to real-world problems of sustained attention. [145].

An issue requiring careful consideration when repeating neurobehavioral tests, is the *practice effect*, i.e. the improvement of performance on retesting which comes in addition to the potential true change in the individual's ability during the period investigated [146]. Unadjusted for, this effect may result in wrongfully attributing improved scores to recovery of function or efficacy of an intervention, when the results are more likely to reflect the effects of test practice [147]. Although widely known, the literature offers little guidance on how to adjust for this effect [148]. McCaffrey et al. recommend to correct for an initially strong practice effect by providing two or more baseline evaluations, or allow for pre-training before introducing the experimental condition [149]. In this study, we applied both methods. All participants completed a training session before the first baseline tests, and they performed a second "baseline" test after two days off. When analyzing each score, we evaluated the difference between workday 1 and workday 4 versus a combination of the scores from the two baselines. All participants from the three groups were off duty at least two days preceding both baseline tests. We adjusted for a potential practice effect by including the logarithm of the test number (1=day 0, 2=day 2, 3=day 4, 4=day 6) as a covariate, assuming this effect to follow a logarithmic shape, being largest at the first test session. These assumptions were confirmed by visual inspections of the plots.

Another issue that should be considered, is potential individual differences in aptitude for neurobehavioral testing. Individual differences in cognitive functioning during extended work hours are believed to be considerable, based on both observations in laboratories and in workplaces. This implies that the different cognitive processes involved in task performance should be distinguished before overall performance outcomes can be fully understood [36]. Scaling up from laboratory measures of cognitive ability in order to predict complex job performance, e.g. for pilots, is not straightforward. Any cognitive task involves a number of interrelated processes that should be distinguished to understand the underlying factors determining actual performance

[150]. In this study we were not able to control for individual differences regarding vulnerability to sleep, fatigue, and individual aptitude for neurobehavioral testing.

The SART and ACT are both conducted on a computer, and thus lack the resemblance to real life situations. The value of a test is related to whether the demands of the test are related to the necessary skills needed to operate in a real life setting. Thus it is not obvious that a similar pattern of performance as seen on the test would be seen e.g. when operating an aircraft, for which the pilots have received in-depth training, and are highly experienced. These considerations call for caution when interpreting the results from the neurobehavioral tests.

In paper II, we investigated the association between long working days and neurological functioning by multiple outcome variables (12 from the ACT- and 3 from the SART procedure) for an association with long working days. These variables are not independent of each other. We assume that in particular the overall, cued, long and short distance variants of the measures of precision, and the number of correct responses are strongly correlated. We assume RT, on the other hand, to be quite independent of precision and number of errors, because it measures quite different individual characteristics. To reduce the problem with multiple outcomes, we could have considered overall precision and overall reaction time as the main primary outcomes. Generally, conducting a large number of tests with multiple comparisons, increase the probability of obtaining at least one single significant finding. To adjust for multiple testing, we could have used a false discovery rate criteria, like q-values or the Benjamini-Hochberg procedure [151]. In our case, however, we did not observe any significant difference of the outcome measures between day 1 and 4 in the work periods. Thus, the problem of multiple outcome measures were not considered an important issue to discuss.

There is yet much to learn about vulnerability to fatigue and individual differences therein, and several studies have pursued to address this issue. Task impurity is a common focus in these studies, which implies that performance tasks involve several interrelated cognitive processes that needs to be distinguished to understand the causal factors determining performance outcomes. It has been claimed that there is still research to be completed before a comprehensive understanding of task-specific vulnerability to fatigue emerges from laboratory data [36].

It is not evident that test assessment of individual variability translate reliably to a workplace. In populations that are highly trained and also frequently exposed to extended work hours and shift work, practice effects and selection or self-selection effects could result in a bias for retaining only the individuals that are most resistant to fatigue, [80].

9.4 Subjective data (Paper I, II and III)

Questionnaires were used to collect demographic and lifestyle characteristics in the baseline evening, and two work/sleep diaries were completed during the work period.

Subjective data are valuable, as they probably reflect and guide the participants' decisions, reflections, reasoning, and behavior, including the willingness to seek or accept the exposure within the context of this study. However, questionnaires can be crude and inaccurate measuring instruments [122], and may cause information bias. According to Theorell & Hasselhorn [152], it is unclear to what extent self- reported assessments of the psychosocial work environment reflect individual characteristics, and to what extent they reflect true environmental conditions. The validity of a questionnaire as a measure of the variable of interest should preferably be determined in a sample of subjects before the main study is undertaken [123]. In this study, we discussed the content of the questionnaire and the work/sleep diary with both nurses and airline crew members before data collection in order to assure that the included questions were relevant. Most of the questions included in the questionnaires are based on previously validated questionnaires, i.e. QPS Nordic [153] , the Bergen Insomnia Scale [154], and the Samn-Perelli Fatigue Score [155]. Self-reports of fatigue and sleepiness did not differ significantly between pilots and cabin crew members. Considering the difference in physical activity during the work hours, one could have expected that cabin crew would have reported a higher degree of alertness among cabin crew members as activity may prevent e.g. latent sleepiness [57].

Self-reported data may result in report-bias. Subjects may over-report sleep and under-report tiredness due to a concern about employers concern about their fitness for duty. However, the management of the actual airline in this study are clearly expressing a just culture, in which reporting on unfit for duty due to lack of sleep or extreme tiredness is encouraged when needed.

Some questions regarding the specific shift schemes of each participating group, and the subjects' perception and evaluation of different characteristics of their shift schemes, were developed specifically for this study. In this thesis, data from the questionnaires supplement more objective information from the neurobehavioral tests, and HRV-measurements.

9.5 Measurement errors

Several methods have been applied in order to detect and monitor fatigue and risk of fatigue related errors, including subjective and objective measures. Methods to quantitative monitor fatigue include those monitoring physiology and those monitoring behavior [156]. In the present study, we chose to monitor physiological responses by HRV, behavioral responses by the ACT and SART procedures, and fatigue through sleep/work diaries.

Device inaccuracy, environmental conditions in the test setting, and self-reported measurements are all potential sources of errors [157].

Variation in test behavior may occur if the test is set up and supervised by different persons, or if test conditions vary from one time to the next [123]. In the present study, the same member of the research team assisted the participant during the repeated neurobehavioral test sessions. Ideally, all the test sessions should be performed using the same computer, at the same time of the day, in the same test location, and with identical lighting conditions. These prerequisites were met when testing the health care workers. The airline crew members on the other hand, ended their first day of flight duty at slightly different hours of the evening, and at different destinations.

As the work of airline crew to a great extent is computerized, and includes recurrent training and testing sessions during a year, and as the tests were performed on the same computer, and supervised by the same member of the research team, we assume that the varying test hours did not bias the results of this group of workers. However, we cannot ignore that different test locations with different lighting conditions, etc could have influenced the results. Regarding the HRV-measurements, even if one of the researchers carefully demonstrated to the participants how to use the sensor at the baseline meeting, the subsequent handling of the equipment on their own may have reduced the quality of the relevant measurements.

9.6 Confounding

Confounding represents a considerable source of error in medical research, and describes a variable that can cause spurious associations between the exposure and outcome, and may both over- and underestimate any effects [133]. Confounding occurs when an estimate of the association between an exposure and an outcome is mixed up with the real effect of another exposure on the same outcome, the two exposures being correlated. For a variable to be a confounder, it must be associated with the exposure under study and it must also be an independent risk factor for the outcome. Confounding can be dealt with when designing studies or when analysing the results provided that the relevant data have been collected [123].

In this thesis, total duration of breaks (or rather, short duration of breaks) is an independent risk factor for changes of HRV measurements and neurobehavioral function, and it is also associated with number of hours actually worked, and thus may be regarded as a confounder. Age, gender and BMI were regarded as confounders, and were adjusted for in the analyses. Confounding from external control groups was eliminated, as the participants serve as their own controls [63]. However, it is never possible to exclude that unmeasured confounding exists.

10 Ethical considerations

Basic principles of ethics in biomedical research should be carefully considered in all studies involving human beings. One principle is that participation should be voluntary and based on adequate understanding of the study [122]. In the recruitment phase to our study, members of the research team informed potential participants in the nursing home at a staff meeting, and distributed leaflets with comprehensive information.

Participation of airline crew members was recommended both by the labor unions and the company's management. The management sent an email to all crew members. Representatives from the research team were present at the crew base on several occasions, to recruit participants and to inform about the study.

The information included a procedure description, should any HRV-measurements indicate disease, i.e. the participant would be advised to consult their GP.

Except for a possible skin-irritation from the HRV sensor pads, there were no other hazards associated with participation in this study.

Following the information sessions concerning the study, including the right to withdraw from the study any time, informed written consent was collected from each participant. The study protocol was approved by the Regional Committee for Medical Research Ethics (2014/1508/REK sør-øst B).

11 Conclusions

Based on the analyses within this study, exposure to four consecutive long work days

- did not indicate increased cardiovascular strain among health care workers
- Indicated increased cardiovascular strain among the airline crew, most prominent among cabin crew members.

There were no indications of insufficient recovery after the work days, or after the work period, in any of the participating groups.

Among pilots, subjective reports of high demands and low decision latitude were associated with indications of increased cardiovascular strain. Among cabin crew, a higher number and longer duration of breaks during the work period, were associated with indications of decreased cardiovascular strain.

As a function of work hours alone, the neurobehavioral functioning did not deteriorate during the four-day work period in neither pilots nor cabin crew members.

Work content (number flight sectors in the work period) was associated with an increase in measured reaction time among pilots and cabin crew members.

Reported fatigue and sleep duration did not influence neurobehavioral performance among the airline crewmembers.

Additional findings showed that among cabin crew members, longer duration of sleep before the work days was associated with indications of lower cardiovascular strain.

These results of this thesis emphasizes the need to consider the following factors when designing work schedules:

- Sufficient number and duration of breaks during a work shift
- Limited number of flight sectors during a work shift and a work period
- Facilitate for sufficient recovery and sleep between consecutive shifts

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Industrial Health 2018, **56**, 1–10

Original Article

Fluctuations in heart rate variability of health care workers during four consecutive extended work shifts and recovery during rest and sleep

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Received June 23, 2017 and accepted October 13, 2017
Published online in J-STAGE October 21, 2017

Abstract: The aim of this study was to investigate fluctuations in heart rate variability (HRV), which reflect autonomic nervous system (ANS) function and potential psychological and physical strain, among 24 health care workers during work and sleep during four consecutive extended work shifts. Data included 24/36/12 h of HRV measurements, two logbooks, and a questionnaire. A cross-shift/cross-week design was applied. HRV was measured during work, leisure time, and sleep. The HRV data included time-domain [mean RR, SD of normal to normal R-R intervals (SDNN), and root mean square of the successive differences (RMSSD)] and frequency-domain [low frequency (LF)/high frequency (HF) ratio] parameters. HRV parameters revealed significant differences among work, leisure time, and sleep. Mean RR, RMSSD, and SDNN values were lower and the LF/HF ratio was higher on the first versus last day of the work period; however, the differences were most prominent in the morning hours. The results indicate higher levels of cardiovascular stress on the first versus fourth day of the working period, and measurements at night indicate a satisfactory recovery from the extended shifts.

Key words: Autonomic nervous system, Stress, Health care workers, Extended working hours, Compressed work week

Introduction and Background

Non-standard work schedules are becoming an increasingly frequent aspect of modern society and have become more diverse and irregular, including night shifts, extended daily and weekly working hours, and less time for rest and recovery[1]. Extended working hours may include long working *days*, long working *weeks* (exceeding 40 h), or *compressed* working weeks (long daily hours and normal weekly working hours)[2]. The use of extended daily working hours and extended or compressed working weeks followed by several days off has traditionally been practised in the Norwegian offshore sector[3, 4] and within the aviation sector[5]. The use of similar work schedules has, in recent years, increased in the health care sector, construction sector, and service sector due to production benefits or the clients' or patients' need for continuity in care[4].

While expressing their concern regarding possible

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adverse health effects, the social partners in Norway are granting an increasing number of health institutions exemptions from the minimum daily rest of 11 h[4]. Many nursing homes in Norway have introduced shift schemes, including several extended work shifts, resulting in less daily rest during the work period.

Among both employers and employees, there is an increased request for such work schemes. Perceived positive effects may include increased time off between work periods, more time with their families, less commuting time and cost, and fewer shift handovers[2]. Extended working hours and shift or night work are well-established risk factors for workplace accidents and several negative health effects, including cardiovascular diseases (CVDs)[6]. Several studies of nurses with extended work hours have demonstrated both short-term and long-term detrimental effects on sleep, performance, and safety among both nurses and their patients[7–9].

Shift and night work may be particularly problematic if the time for rest and recovery between the shifts is shortened[10]. Associations between long working hours and an increased risk of CVD have also been described[11]. However, it is unclear to which degree these effects are related to risk factors of CVD, such as psychosocial and physiological strain, or to detrimental behavioural changes with respect to sleep, physical activity, and nutritional or smoking habits[12–14]. Thus, it is important to differentiate between the effects of the psychological and physiological workload and the behavioural changes due to the organization of the working hours[2, 15, 16].

Heart rate variability (HRV) is the variation in the beat-to-beat interval of the heart. It represents a reliable reflection of the many physiological factors modulating heart rate (HR). HR is controlled by the sinoatrial node, which is modulated by both the sympathetic and parasympathetic pathways of the autonomic nervous system (ANS). Sympathetic activity tends to increase HR and decrease HRV, whereas parasympathetic activity decreases HR and increases HRV. Measurements of HRV provide a means of observing the interplay between the sympathetic and parasympathetic pathways of the ANS[17] and may also be regarded as an indicator of current disease or a marker of subclinical cardiac disease[17, 18].

Different external stressors affect HRV by causing increased activity in the sympathetic nervous system, which is reflected in the HR and HRV. Subtle changes in cardiac autonomic function due to potential physical or psychological strain during work and recovery during sleep may be detected by analysing HRV measurements[6, 10]. HRV measurements are non-invasive and a relatively simple procedure for evaluating cardiac autonomic function[19].

Significant differences in the HRV parameters between work and sleep periods have been observed in several studies[20–22]. HRV patterns in nurses during normal-length day and night shifts show similar patterns regardless of the type of shift but are dependent on the activity level. HRV thus seems to be modified by levels of physical activity more than diurnal variations[21, 22].

Studies of HRV among workers with extended working hours have shown that extended hours of night work, in particular, may lead to decreased HRV[10, 23]. However, a Finnish study of HRV among female Finnish nurses with shift schemes including both normal and extended day shifts showed only minor differences in HRV parameters between nurses in normal and extended shifts. This may possible be explained by an individual adaptation to the extended shifts or the more flexible organization of duties that is possible during the extended shifts[15].

Our hypothesis is that four consecutive extended day shifts will increase cardiac strain.

The aim of this study is to assess associations between exposure to consecutive extended workdays and the cardiac stress response, as measured by HRV parameters. This includes comparisons of HRV parameters during work and recovery the actual days and nights.

Material and Methods

When a new nursing home opened on the west coast of Norway in 2012, a new temporary shift scheme was introduced. The shift scheme was to be evaluated after 2 yr. We invited all involved workers to participate in the study. The shift scheme consisted of four consecutive day shifts (D) followed by 7 d off (-) and three day shifts followed by another 7 d off (DDDD -------DDD -------) over a period of three weeks. The duration of the day shifts was 14 h. In addition to the 30-min lunch break, the workers were entitled to a one-hour break in the afternoon during which they could leave the ward and had access to a quiet room where they could lie down to rest. Each participant was followed during the four consecutive extended shifts from Thursday to Sunday. Members of the actual day-teams ended their last day of duty on Sunday evening, and a new day-team started on the following day. The members of every new day-team arrived half an hour before their shift started to read the reports from the previous day and night shifts. The turnover of patients was high, as most of the patients of the somatic wards were short-term (usually 14 d) inpa-

Table 1. Participant characteristics (N=24)

	Registered nurses/social workers (N=8) 33%	Nurses assistants/apprentices (N=16) 67%	All (N=24) 100%
Males	1	2	3
Females	7	14	21
Mean age	40.5 (SD 11.9)	42.6 (SD 13.1)	41.9 (SD 12.5)
Current smokers	1 (13%)	6 (38%)	7 (29%)
Mean BMI (kg m-^{2})	26.0 (SD 4.1)	26.3 (SD 3.7)	26.2 (SD 3.7)
Married/cohabitant	6 (75%)	12 (75%)	18 (75%)
Children <18 yr living at home:	6 (75%)	7 (44%)	13 (54%)
Frequent excessive workload	2 (25%)	4 (25%)	6 (25%)
Physical exercise>1 h/wk	6 (75%)	7 (44%)	13 (54%)
Pain in neck, shoulder, upper back last year	2 (25%)	8 (50%)	10 (42%)
Pain in neck, shoulder, upper back last month	2 (25%)	6 (38%)	8 (33%)
Headache, migraine last year	4 (50%)	4 (25%)	8 (33%)
Headache, migraine last month	4 (50%)	3 (19%)	7 (29%)
Sleep problems last year	2 (25%)	4 (25%)	6 (25%)
Sleep problems last month	1 (13%)	4 (25%)	5 (21%)

tients. One of the four wards was designed specifically for patients with dementia, with increased staffing due to potential aggression and violence.

A total of 51 health care workers were included in this temporary shift plan. Workers taking any medication with known effects on cardiovascular function were excluded from the study (2). Five chose not to participate due to health problems or personal reasons. Only one out of the six workers who left the nursing home during the data collection period stated the shift scheme as a reason. The other five workers were offered permanent employment elsewhere. In addition, three apprentices were relocated during the study period. These nine workers were replaced by new employees, whom were included in the study. The resulting sample consisted of 44 health care workers.

HRV measurements from 20 subjects were excluded due to poor quality of the data. Hence, the final sample consisted of 24 subjects: 3 men and 21 women; 8 registered nurses/social workers; and 16 assistant nurses/apprentices. Table 1 shows the characteristics of the participants.

The study design was a cross-shift/cross-week design where the participants served as their own controls. Information about the study and the invitation to participate in the study were given at a staff meeting. The director of the nursing home encouraged participation and informed that the municipality would compensate for their participation beyond the planned working hours, i.e., the baseline meeting.

Participation started at a baseline meeting the evening before the four workdays began. Each participant completed a questionnaire, which included questions on individual characteristics, such as marital status, number of children living at home, age, weight, smoking habits, physical activity, duration of current position, habitual sleep pattern, and self-reported health problems during the previous four weeks and the previous year. The questions were based on validated questionnaires such as the QPS Nordic[24], Karolinska Sleepiness scale[25], and Bergen Insomnia Scale[26] in addition to questions that were developed specifically for this study.

HRV data were collected by eMotion 3D-sensors, which were produced by Mega Electronics Ltd., to assess cardiovascular stress, strain, and recovery during work, leisure, and sleep.

Information and demonstrations regarding the application and activation of the HRV-sensors were given by a member of the research team, whom also activated the first sensor at the baseline meeting. The second HRV measurement (HRV2) was performed from the morning of the first work shift and deactivated the next morning. On the morning of the fourth shift, the participants activated another sensor, which was deactivated the next morning (HRV3). On the third day off, the participants activated the fourth sensor at night before sleep and deactivated it the next morning (HRV4).

Logbooks developed for this study were completed by the participants during the first and fourth days of their working period. The logbooks included questions about sleep length and sleep pattern during the previous night; physical activity during leisure time; commuting time; start and stop times of the shift; episodes of heavy physical workload at work; the number and time/duration of breaks;

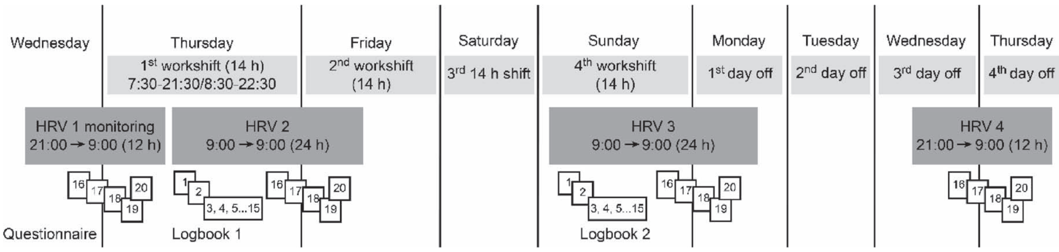

Fig. 1.

Table 2. Selected heart rate variability measures

Measure	Description
Time – domain	
HR (min^{-1})	Mean heart rate in beats per minute. Measure of physiological and psychological cardiac strain. Lower HR at rest and during physical strain implies more efficient heart function and better cardiovascular function.
Mean RR (s)	Mean of selected beat to beat (RR) interval series inversely proportional to HR.
RMSSD	The root mean square of differences of successive RR intervals. RMSSD evaluates differences between successive RR intervals and reflects short-term variations. Low value indicates high cardiovascular strain.
SDNN	SD of normal heart beat intervals. Gives an estimate of overall HRV not distinguishing between changes due to reduced vagal tone or increased sympathetic activity. Low value indicates high cardiovascular strain.
Frequency-domain	
LF and HF	Low frequency power demonstrates sympathetic and vagal activation. High frequency power is synchronous with respiration and is modulated by the vagal tone. High LF indicates high cardiovascular stress. High HF indicates low cardiovascular strain.
LF/HF ratio	LF/HF ratio describes ratio of LF and HF powers. High LF/HF ratio indicates high cardiovascular strain.

food intake; coffee and tobacco consumption; and self-reported health problems, including perceived stress. The study protocol was approved by the Regional Committee for Medical Research Ethics. Participants provided written informed consent. Data collection occurred from November 2014 to February 2016.

The measured segments represent different time points during the workday, time off, and sleep: time segments 1 to 14 represent the workday; time segments 9 – 10 represent the one-hour break; time segment 15 is the period before falling asleep; time segments 16 to 19 represent hours of sleep; and time segment 20 indicates the time of awakening the next morning (Fig. 1). The nights were numbered as follows: night 0: the night after baseline; night 1: the night after the first work day; night 4: the night after the fourth work day; night 7: the night after two days off.

HRV parameters

HRV was assessed using three time-domain parameters and one frequency-domain parameter (Table 2). All HRV parameters were computed according to published guidelines[27] (Table 2).

Data preparation and statistical analysis

HRV parameters were investigated during a period of four consecutive 14-h work shifts to evaluate the following:

- Possible differences between work day one and work day four, for each time segment during the whole day.
- Possible differences between the baseline night (night 0) and the nights 1, 4 and 7 respectively, for each of the first four hours of sleep.
- Possible differences between the baseline night (night 0), and the nights 1, 4 and 7 respectively, for the awakening hour.

HRV data were visually inspected to exclude artefacts. Nineteen 10-min time segments that were free of artefacts from each workday were analysed. The HRV data were analysed using Kubios HRV analysis software[28]. SPSS Statistical Package for Windows 24.0 (SPSS Inc, Chicago, IL, USA) was used to analyse the self-reported data from the questionnaire and logbooks. Linear mixed models were applied to each of the HRV measurements, separately analysing the workday, sleep, and awakening hours. All analyses were adjusted for gender, age, body mass index (BMI), and included a random intercept for subjects. Additional analyses adjusted for varying HR, by adding a linear and quadratic term. Linear mixed models were analysed using the lme4 package (version 1.1-12) in R (version 3.3.3) (R-project.org).

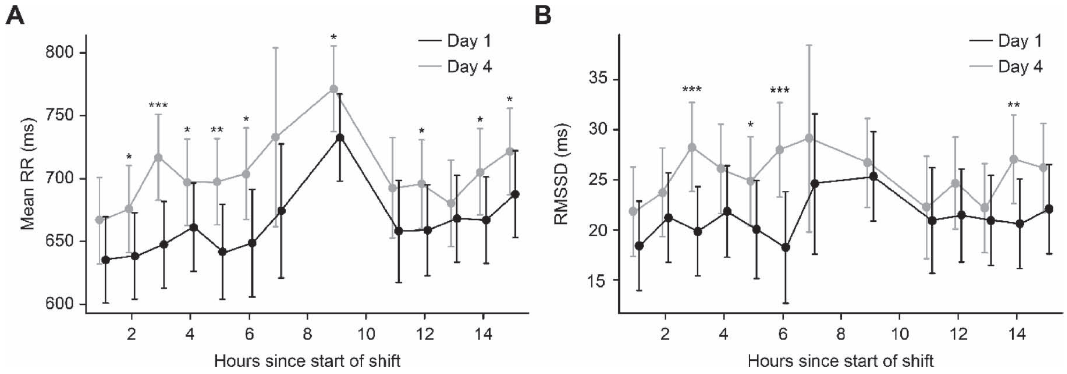

Fig. 2.

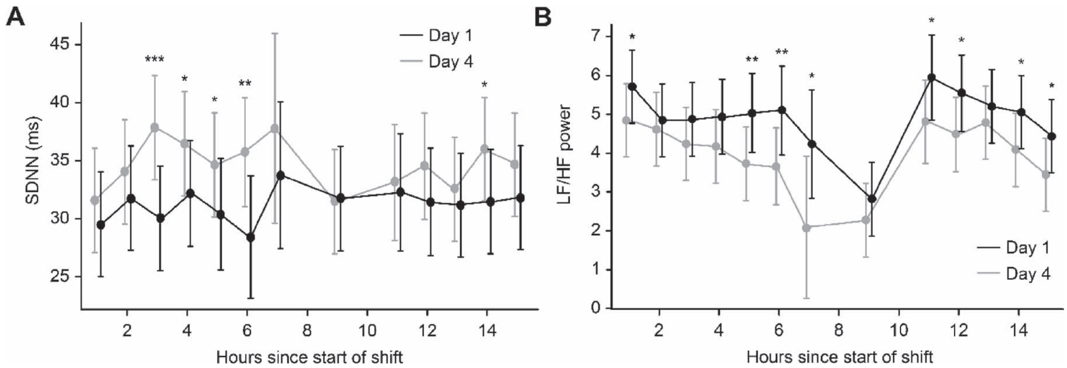

Fig. 3.

Results

We found no significant differences between the two groups in age and BMI using Two samples Wilcoxon rank-sum test. Neither did we find any significant differences in any of the other variables in Table 1 using Fishers-exact test. Due to this, the two groups were analysed as one.

The beat to beat interval (RR) was significantly higher on the fourth workday at time segments representing most of the workday compared to the first workday (Fig. 2A). The root mean square of the successive differences (RMSSD) was at its lowest in the morning when the shift starts on both the first and fourth workdays, but it was considerably lower on the first compared with the fourth work-day (Fig. 2B).

The SD of normal to normal R-R intervals (SDNN) was lower during the whole first workday compared to the fourth workday (Fig. 3A). The low frequency (LF)/ high frequency (HF) ratio was consistently higher on day 1 compared to day 4 (Fig. 3B). A significant decrease in HR, and a decrease in the LF/HF ratio were observed around the time of the afternoon break compared to the start of the shift in the morning. When comparing the time segment before the one-hour break with the time segment just after the break, we did not detect any significant differences in RR, RMSSD, or SDNN on neither the first nor the fourth workday. However, we observed a significantly higher LF/HF ratio after the one-hour break on the fourth workday compared to that on the first workday (Table 3).

HRV parameters during four nights

For all parameters, Table 4 shows only minor differences between the four nights during the first four hours of sleep (time points 16 – 19) except for a significant increase in SDNN at time point 18 the night after the first work day compared to the baseline night. A significant increase in LF/HF was observed at the time of awakening in the morning (time point 20) of the second workday versus the morning of the first workday (night 1 vs 0). However, a significant decrease in LF/HF was observed at the time of awakening in the morning of the first day off compared to the morning of the first workday (night 4 vs 0). The mean RR, RMSSD and SDNN were significantly increased at the time of awakening on the morning of the first day off.

Table 3. Analyses of differences of mean SDNN, mean RR, RMSSD, and SDNN between workday 1 and workday 4, for each time segment during the day (9–10 is time of rest). N=24.

Hour	LF/HF		MeanRR (ms)		RMSSD		SDNN (ms)	
	B (95 % CI)	p	B (95 % CI)	P	B (95 % CI)	p	B (95 % CI)	p
1	−0.86 (−1.7, −0.048)	0.04	32 (−0.91, 64)	0.06	3.4 (−0.89, 7.6)	0.12	2.1 (−1.5, 5.6)	0.25
2	−0.22 (−1, 0.59)	0.59	37 (4.9, 70)	0.03	2.6 (−1.7, 6.8)	0.24	2.3 (−1.3, 5.8)	0.21
3	−0.64 (−1.5, 0.18)	0.12	70 (37,100)	<0.01	8.4 (4.2,13)	<0.01	7.8 (4.3,11)	<0.01
4	−0.76 (−1.6, 0.07)	0.07	36 (2.5, 69)	0.04	4.2 (−0.13, 8.6)	0.06	4.2 (0.63, 7.9)	0.02
5	−1.3 (−2.2, −0.41)	0.01	56 (20, 92)	<0.01	4.8 (0.13, 9.5)	0.05	4.2 (0.33, 8.1)	0.03
6	−1.4 (−2.5, −0.37)	0.01	56 (13, 99)	0.01	9.7 (4.1,15)	<0.01	7.3 (2.7,12)	<0.01
7	−2.1 (−4.2, −0.1)	0.04	58 (−23,140)	0.16	4.5 (−6.1,15)	0.40	4 (−4.8,13)	0.37
Rest	−0.54 (−1.4, 0.27)	0.19	39 (6.4, 71)	0.02	1.4 (−2.9, 5.7)	0.52	−0.27 (−3.8, 3.3)	0.88
11	−1.1 (−2.2, −0.035)	0.041	35 (−9.2, 78)	0.12	1.3 (−4.4, 7)	0.66	0.86 (−3.9, 5.6)	0.72
12	−1.1 (−1.9, −0.19)	0.02	37 (2.1, 72)	0.04	3.2 (−1.3, 7.8)	0.17	3.1 (−0.68, 6.9)	0.11
13	−0.42 (−1.2, 0.39)	0.31	12 (−21, 45)	0.47	1.2 (−3.1, 5.5)	0.58	1.3 (−2.2, 4.9)	0.46
14	−0.96 (−1.8, −0.15)	0.02	38 (5.7, 71)	0.02	6.4 (2.2,11)	<0.01	4.5 (0.97, 8)	0.01
15	−0.99 (−1.8, −0.18)	0.02	34 (1.2, 66)	0.04	4.1 (−0.16, 8.4)	0.06	2.8 (−0.69, 6.4)	0.12

B: estimate of difference between day 4 and day 1

Linear mixed model analyses with random intercept for subject and adjustment for gender, age and BMI.

Table 4. Analyses of differences of mean SDNN, mean RR, RMSSD, and SDNN between the baseline night (night 0) and nights 1, 4 and 7 respectively, for each of the first hours of sleep (16–19), and for the time of awakening (20). N=24.

Night*	Time period	LF/HF		meanRR (ms)		RMSSD		SDNN (ms)	
		B (95 % CI)	p	B (95 % CI)	p	B (95 % CI)	p	B (95 % CI)	p
1 vs 0	16	0.13 (−0.69, 0.94)	0.76	19 (−18, 56)	0.32	1.1 (−5.9, 8.1)	0.75	1.2 (−4.5, 6.8)	0.68
	17	−0.31 (−1.1, 0.51)	0.46	19 (−18, 56)	0.31	2.2 (−4.8, 9.2)	0.53	2.6 (−3, 8.2)	0.37
	18	0.18 (−0.64, 0.99)	0.67	23 (−14, 60)	0.22	5.1 (−1.9, 12)	0.15	6.3 (0.7, 12)	0.03
	19	0.74 (−0.077, 1.6)	0.08	2.5 (−35, 40)	0.90	1.1 (−5.9, 8.1)	0.76	1.6 (−4.1, 7.2)	0.59
	20	2.2 (0.65, 3.8)	<0.01	14 (−58, 85)	0.71	2.3 (−11, 16)	0.74	4.6 (−6.2, 15)	0.40
4 vs 0	16	−0.18 (−0.99, 0.64)	0.67	36 (−1.4, 73)	0.06	3.7 (−3.3, 11)	0.30	1.8 (−3.8, 7.5)	0.52
	17	−0.76 (−1.6, 0.053)	0.07	20 (−17, 57)	0.29	1.2 (−5.8, 8.2)	0.74	1.9 (−3.8, 7.5)	0.52
	18	−0.085 (−0.9, 0.73)	0.84	19 (−18, 56)	0.32	2.7 (−4.2, 9.7)	0.44	4.2 (−1.4, 9.8)	0.14
	19	0.097 (−0.72, 0.91)	0.82	0.48 (−37, 38)	0.98	−1.3 (−8.2, 5.7)	0.73	−2.4 (−8, 3.3)	0.41
	20	−2 (−3.6, −0.46)	0.02	280 (210, 350)	<0.01	19 (5.5, 32)	<0.01	18 (7.6, 29)	<0.01
7 vs 0	16	−0.02 (−1.3, 1.3)	0.98	27 (−33, 87)	0.38	−1.6 (−13, 9.7)	0.78	0.28 (−8.8, 9.4)	0.95
	17	−0.78 (−2.1, 0.54)	0.25	−3.2 (−63, 57)	0.92	0.38 (−11, 12)	0.95	0.95 (−8.1, 10)	0.84
	18	0.022 (−1.3, 1.3)	0.97	30 (−30, 89)	0.33	2.7 (−8.6, 14)	0.65	6 (−3.1, 15)	0.19
	19	0.54 (−0.78, 1.9)	0.42	25 (−35, 85)	0.42	−2.4 (−14, 8.9)	0.68	0.49 (−8.6, 9.6)	0.92
	20	−0.4 (−1.8, 1)	0.59	230 (170, 300)	<0.01	11 (−1.6, 23)	0.09	11 (1.6, 21)	0.02

*Night 0: The night after baseline, night 1: The night after the first work day, night 4: The night after the fourth work day, night 7: The night after three day off

B: estimate of difference between day 4 and day 1

Linear mixed model analyses with random intercept for subject and adjustment for gender, age and BMI.

Furthermore the mean RR and SDNN showed a significant increase the morning on the fourth day off compared with the awakening time of the first workday (night 7 vs 0).

HRV parameters of the three men were not statistically significantly different from those of the women. Older subjects had a statistically lower mean RR. Higher BMI was associated with statistically increased mean RR and SDNN.

Reported sleep and health issues

The average duration of sleep was 5.8 h the night before the first workday (min 3, max 7.5 h), and it increased to 6.5 h (min 5 and max 8 h) the night before the fourth workday. Fifteen participants (65%) reported a sleep pattern including one or more of the characteristics described in Table 5 the night preceding the first workday, and 12 participants (50%) reported such a sleep pattern the night preceding the

Table 5. Reported sleep patterns the nights preceding Day 1 and Day 4. (N=24).

	Night before Day 1	Night before Day 4
≥30 min falling asleep	10 (44%)	8 (33%)
≥30 min awake in between sleep	8 (35%)	4 (17%)
Awakening ≥30 min before wanted	9 (38%)	4 (17%)

fourth workday.

Five (21%) participants reported having general sleep problems the night preceding the first workday, and four (17%) participants reported sleep problems the night preceding the fourth workday. No significant difference was observed in the number of participants reporting little or no stress between the first and the fourth workdays. All 24 participants stated that they were happy with the current shift scheme. However, two participants (9%) reported difficulties in balancing their work and private lives. Six participants (25%) reported that they rarely or never experienced an excessive workload, 12 (50%) reported that they sometimes experienced an excessive workload, and the remaining six (25%) reported that this occurred quite often.

Discussion

The main finding in the present study was the higher level of cardiovascular stress during the first workday compared with the fourth workday, as indicated by the significantly lower values of mean RR, SDNN, and RMSSD and by the significantly higher LF/HF ratio on the first workday. Our findings did not support the contention that consecutive extended day shifts increase cardiac strain under the present work conditions.

HRV parameters at night were analysed by comparing the values of the first four hours of sleep in the night preceding the work period with the corresponding hours after one and four workdays as well as after three days off. Only minor differences were observed in the HRV patterns during sleep between the four nocturnal time points that were evaluated. Greater sympathetic activation of ANS was observed during work than during sleep. These results are in accordance with the study of nurses by Ito and coworkers, which showed significant differences in the HRV parameters between the work and sleep periods[21]. Bilan and coworkers reported a strong influence of physical activity on the circadian changes in HR[29]. HR and HRV are also influenced by posture. Compared with the supine position, the HRV recorded in the standing position shows LF/HF values that indicated sympathetic augmentation and vagal attenuation[30]. In an attempt to disentangle the effect of HR on HRV, we adjusted for HR in the analyses of RMSSD, SDNN, and LF/HF. The difference between the first and the fourth workday were reduced, but remained statistically significant for RMSSD and SDNN at several timepoints during the day.

If the participants did not achieve sufficient recovery during sleep at night, one would expect to see decreased values of the baseline mean RR, SDNN, and RMSSD and an increased LF/HF ratio during sleep on nights 2 and 3 compared to the baseline nights 1 and 4. However, the minor differences among the HRV-values during the different nights indicate that the participants in this study recover well from the long shifts.

In agreement with previous studies, higher values of the LF/HF ratio were observed upon awakening and during the morning and afternoon hours of both workdays[29, 31]. However, the LF/HF ratio was significantly higher on the first compared with the fourth workday. Mean RR, SDNN, and RMSSD were significantly lower on the mornings the participants had to go to work compared to those on the mornings of their days off. The difference in sympathovagal balance between the awakening time of mornings preceding workdays and that preceding days off indicates that the participants are showing more physiological stress during the mornings of workdays, probably due to vagal withdrawal.

HRV and cortisol are two different physiological markers of stress that experience diurnal variation. Cortisol shows variation during the day, and groups with a stressful or high workload often exhibit increased cortisol levels, particularly in the morning[32, 33]. Bilan and coworkers[29] evaluated the diurnal fluctuations of HRV in healthy people and found a peak in the morning when studying frequency-domain HRV parameters. Their study revealed that the ratio between LF and HF peaked between 6 and 9 a.m. and between 4 and 6 p.m., with the smallest values between midnight and 5 a.m. In accordance with this, in the present study, we observed a peak in the early morning and late afternoon on both workdays one and four; however, the peak was more prominent on workday 1 (Fig. 3B).

Åkerstedt[34] claims that feeling stressed is closely related to impaired sleep. Physical stressors, such as sleep deprivation and overtime work, require an immediate systemic reaction. The ANS responds to both psychological and physical stressors and may result in cognitive, emotional or somatic consequences[35]. Åkerstedt[36] notes that the anticipation of high demands or efforts the next day also seems to be important. He claims that the sleep before early morning shifts is often disturbed. Difficulties of having to rise early in the morning seem to be associated with the anticipation of stressful events[34, 36]. The health workers in the present study start their first morning shifts at 7:30. Although they have a relatively short commuting time to work (average 15 min), the extended shifts provide a rest time between the shifts limited to 10 h. Considering the time spent commuting, winding down, and possibly performing some daily domestic chores, the time left for sleep between the shifts is limited. The difference in sleep length before and after the work period, corresponds to the fact that 65% of participants reported disturbed sleep the night preceding the first workday versus 50% the night preceding the fourth workday.

There was no handover meeting or overlap between teams in the actual nursing home. This, together with other stressful factors mentioned in the methods section, could cause an anticipation of high demands, particularly during the first working day, acting as a psychological stressor that potentially contributes to cardiovascular stress. Mornings and evenings represented the busiest periods of the shifts in all wards due to the morning and night care of the patients. In the morning, patients need assistance to get out of bed, to get washed and dressed, and with morning care in general. Administration of the patients' medications, which occurred during the morning hours of the first workday, may have potentially contributed to additional psychological stress.

The one-hour breaks in the afternoon between 3 p.m. and 5 p.m., or at time segments 9 and 10 in (Fig. 2A and B), seem to lead to reduced levels of cardiovascular stress during both workdays one and four; the positive effects are shown by statistically significant differences; decrease in HR, increase of RR, and increase of RMSSD, and decrease of the LF/HF ratio around the time of the afternoon breaks compared to the start of the shift in the morning. The lower cardiovascular stress in the afternoon coincides with the ability to lie down during their break, which most participants did[21, 37]. When comparing the time segment before the one-hour break with the time segment just after the break, we did not observe any significant differences in RR, RMSSD, and SDNN on any of the actual workdays. The significantly higher LF/HF ratio after the one-hour break on both workdays could potentially reflect greater physical activity and potential mental stress due to work-related tasks in the afternoon and evening, such as dinner serving, the administration of medications, and the general night care of patients, including helping them to bed. The midday hours before the one-hour break seemed to be quieter than the hours during the morning, late afternoon, and evening.

The elevated level of cardiovascular stress at the time of awakening on the first workday was significantly reduced at awakening time on the second workday and on the first day off; cardiovascular stress appeared to be somewhat increased at awakening time after three days off. Factors outside of work could have also influenced the increase in cardiovascular stress in the morning after three days off. Most of the participants were women, 75% of them were married/cohabited, and 54% had children under the age of 18 living at home. Although only 9% of the participants reported problems in balancing work with family life, one cannot exclude that factors outside of work might represent an issue[38].

When the human nervous system perceives an experience as stressful, physiological and behavioral responses are initiated, leading to allostasis and adaptation. Stressful experiences over time may cause an allostatic load, and such sustained stress could promote a blunted response that is a kind of non-adaptive response to stressor stimuli[39]. A working-time schedule like the one in the present study could possibly represent a chronic stressor, and as such potentially explain the vague physiological response after the first day of work. However, none of the health care workers in our study has had this work schedule for more than two years, and it is questionable if two years represents a relevant time span to produce such effects.

In previous studies, decreased values in HRV parameters are reported from the age of 60[40]. In the present study, however, the mean age was 41.9 yr old with only one individual over 60 yr of age. Age had a significant influence on only mean RR ($p \leq 0.01$).

A strength of this study was the use of a crossover design that eliminates uncontrolled confounding that stems from the use of an external control group[41]. Furthermore, the study was conducted in a real-life situation in which we had detailed exposure information. Limitations include the small sample size and potential uncontrolled confounding of sex hormone levels[21] and the stages of the menstrual cycle among the female participants. Leicht and coworkers found a correlation between oestrogen levels at the time of ovulation and HRV measurements[42]. However, in that study, the normal cyclic variations in endogenous sex hormone levels during the menstrual cycle were not significantly associated with changes in cardiac autonomic control as measured by HRV[42].

HRV measurements from 20 participants had to be excluded due to poor quality of the data. However, the characteristics of this group did not differ from those of the included participants.

The study demonstrates higher cardiovascular stress during the first versus the last of four consecutive extended work shifts. The difference was most notable in the morning hours. Measurements at night indicate a satisfactory recovery from the extended shifts.

The analyses did not reveal any adverse effects on HRV parameters from a shift scheme consisting of a compressed week in which the shifts include an extra one-hour break with opportunities to rest while lying down.

The results of this study should be interpreted in the context of the favourable physical and organizational determinants of work stress that are offered in the nursing home in question. Little is known about the possible adverse effects from such shift schemes with a considerably higher workload. At the time of the data collection, the shift plan had been in use for only two years; hence, little is known about possible negative long-term effects.

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III

Cardiac autonomic activity in commercial airline crew during an actual flight duty period

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Background: The work schedules of airline crew members include extended workdays, compressed work periods and limited time for recovery, which may lead to cardiovascular strain and fatigue. The aim of this study was to evaluate changes in heart rate variability (HRV) during work and sleep, and with respect to work characteristics and breaks.
Methods: We followed 49 airline crew members during four consecutive workdays of ≥39 h. Data included HRV measurements, a questionnaire, and sleep/work diaries. HRV parameters include root mean square of successive differences (RMSSD), standard deviation of the normal beat-to-beat differences (SDNN), and the low and high frequency ratio (LF/HF).
Results: The results indicate higher levels of cardiovascular strain on the 4th compared to the 1st workday, most prominent among cabin crewmembers. In this group, we observed indications of decreased cardiovascular strain by increasing duration of sleep, demonstrated by increased RMSSD (B=2.7, 95% CI 1.6, 3.8) and SDNN (B=4.4, 95% CI 3.0, 5.7), and decreased LF/HF (B=-0.2, 95% CI, -0.4,-0.01). Similarly, longer duration of breaks was associated with lower cardiovascular strain, indicated by increased RMSSD (B=0.1, 95% CI 0.03, 0.1) and SDNN (B=0.1, 95% CI 0.1,0.1). Among pilots, increased LF/HF indicated higher cardiovascular strain in those who often or always reported of high work load (B= 4.3, 95% CI 2.3, 6.3; and B=7.3, 95% CI 3.2, 11.4, respectively).
Discussion: The results support the contention that the studied work period increases cardiac strain among airline crew. Work characteristics, breaks, and sleep are associated with changes in HRV.

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Keywords: *airline crew, extended working hours, fatigue, heart rate variability,*

As shown in a review by Keclund and Axelsson,[16] a considerable number of studies have documented negative impact of non-standard working time arrangements regarding sleep, fatigue, cardiovascular health, performance, and safety. Schedules of airline pilots and cabin crew are extremely irregular, and involve early starts, long daily working hours, compressed working weeks, short rest periods, all of which may contribute to sleep disorders, strain, and fatigue.[1] Disruption of sleep alters sleep–wake timing and destabilizes physiology.[35]

The autonomic nervous system (ANS) is the primary regulator of heart rate, and there is growing evidence for its role in development of a wide range of diseases.[30] The ANS consists of two major branches; the sympathetic, associated with energy mobilization, and the parasympathetic, associated with vegetative and restorative functions. With long-term strain and incomplete recovery, protracted activation of the sympathetic part of the ANS may potentially increase the risk of cardiovascular diseases (CVD).[17] The sympathetic and parasympathetic branches act antagonistically to preserve the dynamic equilibrium of the vital functions, but may become unbalanced in response to external or internal stimuli or demands. In the cardiovascular system, this dynamic regulation results in the variation of the time intervals between consecutive heart beats, so called heart rate variability (HRV). HRV reflects the balance of the cardiovascular system; sympathetic activity tends to increase heart rate (HR) and to decrease HRV, whereas parasympathetic activity decreases HR and increases HRV.[30]

Measuring HRV is a non-invasive procedure. The HRV measurement is considered a reliable estimator of the ANS status, which enables indirect observation of subtle changes due to stress, strain and recovery.[30] A normal subject shows a good degree of variation of the heart rate, reflecting a good capability to react to external stimuli.[6]

Various occupational factors are believed to modulate workers' cardiovascular health.[31] However, it is unclear to which degree the observed association between irregular working hours and increased risk of CVD is a result of psychological and physiological strain related to the long working hours or other work-environment factors, or to unhealthy lifestyle as a result of shift work, (smoking, low diet quality and low physical activity) which could influence CVD. [33] For studies of shift work and health, it has been recommended to include, in addition to objective assessment of working time, variables concerning sleep,[16] physiological mechanisms, and perceived work-stress.[18] Furthermore, recovery may be evaluated by the variations in HRV during sleep after work and leisure time.

The aim of this study was to evaluate changes in HRV during an actual flight duty period and sleep, and with respect to work characteristics and breaks.

Subjects

The subjects of this study were pilots and cabin crew members in a commercial airline based in Norway. Employees in the airline were informed of the study and encouraged to participate, in an e-mail from the airline's management of flight and cabin operations, and the worker's unions. Subsequently, representatives from the study's project group were present at the crew base at Oslo airport on several occasions, to recruit crew members. Initially 160 crew members agreed to participate. The main criteria for selection of the final sample, were characteristics of the planned flight duty period (FDP) of the enrolled crew members. Every month, personal schedules for the coming 4 weeks are presented to all crew members. Schedules eligible for the present study were those including a four-day work period of at least 39 work hours, in which the first workday was at least 10 hours, and including only short-haul flights operated by Boeing 737 aircraft. Work periods consisting of four days of flight were chosen, as these were the most common among cabin crew members at the time we started our data collection. Most pilots with a variable roster pattern would also have a majority of four-day work periods.The >39 hours for the four day period was chosen as this represented a compressed work period. The >10 hour first work day was chosen to focus on workdays well exceeding the 7.5-8 hour limits for normal work days in the country where these airline crew members are based. We chose short haul operations only, as we sought to avoid night work and time differences. We sought to ensure as similar work procedures as possible, thus the study was limited to only one aircraft type.

The final sample consisted of 59 healthy airline crew members, 18 pilots (16 men and 2 women) and 41 cabin crew members (6 men and 35 women). A cross-shift/cross-week design, in which the subjects served as their own controls, was applied. The study period was a work period of four days. The study protocol was approved by the Regional Committee for Medical Research Ethics (2014/1508/REK sør-øst B), and the subjects provided a written informed consent.

*Table I here

Procedure

Flowchart of the data collection is shown in figure 1. At baseline, the evening before the actual work period, the subjects completed a questionnaire concerning age, weight, height, health status, physical activity, work experience, and work characteristics. The questionnaire included questions from validated questionnaires such as QPS-Nordic[22] and Bergen Insomnia Scale.[5] During the first and the fourth workday, the subjects completed a work and sleep diary, including check-in and check-out times for duty, commuting time, time and duration of breaks, and irregularities of flights (such as delays). Furthermore, the diary included questions about the duration and quality of sleep. The quality of sleep was determined by a simplified version of the Bergen Insomnia Scale, including reporting episodes of over 30 minutes before falling asleep, over 30 minutes awake periods during the night, and early awakening more than 30 minutes earlier than desired. The Samn-Perelli Fatigue Score (SP) [25] was included in the diary, and the subjects stated their alertness at check-in time, after 8 hours, and at check-out time, according to the following scores: 1) Fully alert, wide awake, 2) Lively, responsive, not at peak, 3) OK, somewhat fresh, 4) A little tired, less than fresh, 5) Moderately tired, let down, 6) Very tired, difficulty concentrate, 7) Completely exhausted.

HRV was measured by eMotion 3D-sensors to assess cardiovascular strain during flight duty, and recovery during leisure time and sleep. The eMotion 3D-sensors were produced by Mega Electronics Ltd, in Kuopio, Finland. The sensor contained an accelerometer, which was utilized to detect onset of sleep, and time of awakening. At baseline, the evening before the first day of flight duty, a member of the research group demonstrated the application and activation of the HRV-sensors, and also activated the first sensor (HRV1), see Figure 1. The sensor was deactivated, and replaced by a second sensor (HRV2) at check-out time after the first day of flight duty. HRV2 was deactivated by the subject before his/her flight duty on the second work day. In the morning of the fourth workday, the subject activated a third sensor (HRV3), and deactivated it the next morning. The subjects were instructed to activate a fourth sensor (HRV4) at bedtime the evening of the second day off, and deactivate it the next morning. HRV measurements were pre-processed and analysed using the Kubios HRV analysis software.[29] The selected HRV measures were chosen according to the guidelines of the Task Force of the

European Society of Cardiology[4] and are described in Table II. HRV data were visually inspected, to exclude artefacts such as missing beats or ectopic beats. Subsequently, 5-minutes time segments free of artefacts, were selected from each work hour during the day, from the first four hours of sleep, and from the wake-up hour in the morning. Finally, hourly mean HRV values were calculated from the selected 5-minutes time segments. In figure 1, boxes numbered 1, 2, 3, 4 represent the mean of 5-minutes time segments during first four hours of sleep, box 5 the time of awakening, and box 6, 7, 8 the working hours during the days.

*Table II here

The following comparisons were made for each HRV-parameter:

i) The difference between the first and fourth workday.

ii) The difference between the baseline night (night 0) and the nights 1, 4 and 6.

iii) The differences between cabin crew members and pilots.

Comparisons of i), ii) and iii) above, with data stratified by work characteristics: duration of breaks, reported decision latitude, and perceived workload.

*Figure 1 here

Statistical analyses

We applied linear mixed models to each of the HRV measurements, for the hours of the workday, the hours of sleep, and for the time of awakening. A random intercept was included for each subject. On the basis of existing knowledge of factors associated with cardiovascular disease,[19, 28] we adjusted for the following variables: Sex, age, and body mass index (BMI). We did additional analyses adjusted for varying HR, by adding a linear and quadratic term. In the present study, the work hours relate to the starting time of the workday, and not the clock hours, as check-in and check-out times vary considerably between the subjects. In mixed model analyses, we chose to collapse work hours 1-3, 4-7 and the work hours 8 until the end of the workday, in order to focus on main trends, and to improve statistical power (few subjects ended their workday at very late hours).

In separate analyses, we studied the effect of workplace characteristics, sleep duration, and duration of breaks during the workdays. Fisher's exact test was used to evaluate potential differences between flight commanders and first officers regarding job control and cardiovascular strain. Linear mixed models were analysed using Stata 15. SPSS' Statistical Package for Windows 24.0 (SPSS Inc, Chicago, IL, USA) was applied for the univariate analyses of the self-reported data from the questionnaire and diaries.

Results

The median number of years the participating pilots have worked in the airline is 26 years (SD 7.7), and the cabin crew members 17 years (SD 11.4). The distribution of socio-demographic variables are shown in Table 1. Reported information from work and sleep diaries are shown in Table III.

*Table III here

The majority of the subjects in both professional groups reported that they felt quite refreshed at the start of both the 1st and the 4th day of the work period (not shown). The mean SP fatigue score was 2.2 both days, where 2 represents “lively, responsive, not at peak”. However, the mean score at check-out time, at both the first and fourth workday, indicated tiredness; SP=4.2 and 4.4 for the cabin crew, and 4.6 and 4.2 for the pilots, where score 4 represents “a little tired, less than fresh” and 5 “moderately tired, let down”.

Irregularities and change of scheduled flights for the subjects resulted in work periods not meeting the criteria for inclusion, and thus reduced the number of subjects. While HRV1 was measured by 40 cabin crew members and 16 pilots, HRV2 was made by 38 cabin crew members and 18 pilots. For HRV3, the number of subjects was reduced to 24 cabin crew members and 12 pilots. HRV4 was measured by 19 cabin crew members and 12 pilots. The reduction in the sample during the work period was due to severe delays, diversions and rescheduling of flights, and to sick leave. In addition, some measurements, particularly day-time measurements, were excluded due to poor quality of the data.

Changes of HRV variables on workday 4 versus workday 1 are shown in Table V. Figure 2 shows the changes in HRV among the cabin crew members.

Mean RR was significantly increased during the first seven hours of the 4th workday among cabin crew members, while among the pilots, we observed a significant decrease in mean RR during the first three hours and after seven hours of duty on workday 4. RMSSD showed a non-significant decrease during all working hours of workday 4 among the pilots, and after the third work hour among cabin crew members, when compared to workday 1.

SDNN decreased significantly among the cabin crew members, after the third hour of duty on the 4th compared to the 1st workday, while only a non-significant decrease was observed among the pilots. A significantly higher LF/HF was seen in the cabin crew members on the after the third work hour throughout 4th workday. The only observed significant differences between pilots and cabin crew members, were lower RR among the pilots during the three first hours (B= -78.7, 95% CI-112.1, -45.3), and during the next four hours of workday 4 (B= -39.2, 95% CI-69.0, -9.4). Table 6 shows changes of HRV variables during the nights after the 1st and the 4th workday, and after two days off, compared with the baseline night (night 0). Changes are tabulated for each of the first four hours of sleep, and for the hour of awakening.

Among cabin crew members, we observed a significant increase of mean RR at the time of awakening both in the morning after night 1, after night 4, and after night 6, when compared to awakening after night 0 (before first workday). Mean RR among the pilots reveals a similar pattern as that for cabin crew members, with a significant increase at the time of awakening both in the morning after workday 1 and 4, and after two days off. For RMSSD among cabin crew members, a significant increase was only observed at the time of awakening after night 6, compared to night 0. Among the pilots, RMSSD was a significantly increased at the third hour of sleep in night 6. For SDNN among both cabin crew members and pilots, there was no difference for the awakening hours after any of the later nights, when compared with the awakening time after night 0. Neither did we observe any significant change of SDNN during sleep in any of the nights 1, 4 and 6, compared to night 0. LF/HF was significantly lower among cabin crew members at the time of awakening after nights 1, 4 and 6, when compared to awakening after night 0, while no difference was observed during sleep. Among the pilots, LF/HF decreased significantly during the second and third hour of sleep the night after workday 1 (night 1), compared to the night before workday 1 (night 0). A significant decrease of LF/HF was also seen during the second hour of sleep in the night after the four days work period (night 4), and during the second and third hour of sleep in the night after two days off (night 6). Observed differences between pilots and cabin crew members during the nights, comprise a lower LF/HF among the pilots from the fourth hour of sleep (B= -1.6, 95% CI -3.1, -0.2) until awakening (B= -2.1, 95% CI -3.8, -0.5) the night after workday 1. The pilots also showed a lower LF/HF than the cabin crew members from the second, third and fourth hour of sleep the night after the last workday; (B= -2.5, 95% CI -4.0, -1.1) (B= -2.0, 95% CI -3.7, -0.3) (B= -2.2, 95% CI -4.1, -0.3) respectively.

* Figure 2 here

*Table IV here

*Table V here

Among cabin crew members, during all of the work shifts, RMSSD, SDNN and LF/HF were all significantly associated with the duration of sleep the previous night, when adjusted for sex, age and BMI. An increase of RMSSD (B=2.7, 95% CI 1.6, 3.8) and SDNN (B=4.4, 95% CI 3.0, 5.7), and a decrease of LF/HF (B=-0.2, 95% CI, -0.4, -0.01) were observed by increasing number of sleeping hours. Among the pilots, we did not observe similar significant changes for any of these parameters. Among the cabin crew members, we also observed an increase in mean RR (B=0.2, 95% CI 0.6, 0.3), RMSSD (B=0.1, 95% CI 0.03, 0.1) and SDNN (B=0.1, 95% CI 0.1, 0.1) by increasing duration of breaks, when adjusted for sex, age and BMI. However, among the pilots, no elevation was observed for any of these parameters.

Reported demand/control factors, such as workload and decision latitude, were associated with variations in LF/HF among the pilots. LF/HF was significantly lower (B= - 4.9, 95% CI -8.7, -1.2) in pilots who rarely perceived the workload as heavy, while an increased LF/HF was seen in pilots who often (B= 4.3, 95% CI 2.3, 6.3) or always (B=7.3, 95% CI 3.2, 11.4) perceived the workload as heavy. A somewhat different pattern was observed regarding decision latitude. LF/HF was decreased both workday 1 and 4 among pilots who reported of rarely being able to influence decisions important for their work (B=-3.5, 95% CI -6.6, -0.3). A decrease was also observed in pilots who reported of often being able to influence decisions important for their work (B=-5.9, 95% CI-10.0, -1.7). Among cabin crew members, the demand/control issues, were not associated with any significant changes of the HRV parameters.

Discussion

In the present study, we identified HRV measures indicating a higher level of cardiovascular strain on the fourth, compared to the first workday, most prominent among the cabin crew members.

In cabin crew members, this became apparent both through decreased SDNN, and an increased LF/HF after the first three hours of duty on the 4th compared to the 1st workday. RR was increased during the first hours of the flight duty on the 4th compared to the 1st workday, which could indicate that the cabin crew members were rested when starting their duty on the 4th workday. This is in line with their subjective reports of feeling alert, and is further supported by their reporting of less sleep disturbances and longer sleep duration the night before the 4th workday. Anticipation of high demands, or having to rise early, may have disturbed the sleep the night before the 1st day of flight duty.[37] The night before the 4th workday, 50% of the cabin crew members stayed overnight in hotels, allowing them to recover undisturbed. Instead of the usual long commuting time, a hotel-to-airport transportation of short duration was at hand. This, and the anticipation of the days off ahead, may partly explain the lower report of sleep disturbances and increased duration of sleep the last night of the duty period. Cardiovascular strain seemed to decrease with longer duration of sleep before the workdays, and with increasing number and duration of breaks among the cabin crew members. We did not observe any correlation between reported work characteristics and HRV-parameters among cabin crew members. A higher overall bodily stress as measured by HRV parameters, was observed on the 4th versus the 1st workday, in spite of the shorter mean duty length, and fewer flight sectors on the 4th day. This may have been influenced by the suboptimal environment in which cabin crew members perform their duty, handling heavy service trolleys in tiny galleys and narrow aisles, sometimes even uphill. Being in the service frontline, and attending to several hundred passengers during each day of flight duty, represents a psychological strain.[7, 34] The continuous exposure to high levels of noise in the aircraft may furthermore cause a shift in cardiovascular regulation towards sympathetic dominance.[9] Days of duty in short-haul operations usually include multiple flight sectors, with a high number of passengers, repeated safety and service procedures, and represent a high workload. The accumulation of work hours, the combined physical and mental workload during the work period, may have contributed to the increased cardiovascular strain the fourth workday among the cabin crew members, in line with earlier research.[13]

For pilots, we observed a somewhat different trend. A decreased mean RR was found on workday 4 compared to workday 1, particularly during the morning and evening hours. In combination with the decreasing trends of RMSSD and SDNN all through the 4th day, this either indicates lack of recovery, or accumulation of strain from workday 1 to workday 4. The pilots reported of later check-in time for duty, less sleep disturbance and the same sleep duration the night preceding the 4th workday, when most of them stayed overnight in a hotel. However, self-reported recovery is not necessarily reflected in physiological recovery as indicated by HRV, as stressors that may lead to HRV-changes indicating increased cardiovascular strain may not result in similar subjective experience of stress.[13]

The lower RR among the pilots compared to cabin crew members during the first seven hours of duty on day 4 compared to day 1, was the only significant differences between the two groups of subjects, in spite of their very different work content.

We attempted to disentangle the effect of HR on HRV by adjusting for HR in the analyses of RMSSD, SDNN, and LF/HF. The differences between the first and the fourth workday were reduced, but remained statistically significant for SDNN and LF/HF among the cabin crew members.

Previous research has shown a correlation between self-reported psychological strain and physiological indicators of strain as measured by HRV.[15] Similarly, in the present study, the reports of a high workload, was often or always associated with increased LF/HF. High job demands, in combination with low work control, is a potential determinant of reduced HRV, and the effect of high job strain has been associated with reduced HRV.

A person's ability to influence what happens in their work environment is a key element in handling work related strain.[8] In the current study, associations were found between very low and very high decision latitude and decreased cardiovascular strain. The participating pilots were either commanders or first officers. While the commanders have full control of decisions, including the ultimate responsibility during a flight, the first officers have less control and less responsibility. A Fischer's- exact test of any potential effect of the job category, did however, not reveal any difference between the two groups in how they reported on the question regarding decision latitude.

Operating an aircraft requires substantial cognitive effort and attention from the pilot, and the take-offs and landings represent the the highest cognitive demand and workload.[23] Changes of HRV are related to both information processing and performance, and appear to be sensitive to increased risk of mental overload.[21] The decreased RR during the first and the last hours of workday 4, may partly be explained by take-offs and landings during these hours. A study of the same subjects, revealed that the number of take-offs and landings was associated with increased reaction times as measured by neurobehavioral tests, indicating increased fatigue, thus supporting that take-offs and landing represent high workload.[12]

The HRV measurements during nights among the subjects in both professional groups, indicate a satisfactory recovery after work. Slow wave sleep, mainly occurring during the first four hours of sleep, is related to recovery,[3] and we therefore analyzed HRV parameters from each of these hours. We observed greater sympathetic activation of the ANS during work than during sleep, in line with earlier research. [11, 14] This may partly be due to the strong influence of physical activity on the circadian changes in HR.[2] HRV is also influenced by posture, as HRV recorded in the standing position shows higher LF/HF values compared to the supine position.[20]

In a study of pathways from circadian strain to morbidity, Puttonen et al [24] concludes that shift work can induce psychological circadian strain, due to a disrupted work/life balance. While 39%

of the cabin crew members in the present study, and 44% of the pilots reported of a work/family conflict, no significant associations were observed between such conflict and any of the HRV parameters, neither among cabin crew members nor among pilots (not shown).

Both cabin crew members' and pilots' ability to achieve sufficient sleep, in spite of the irregular working hours, may probably be considered a healthy worker effect.[26] While the included subjects in the course of their long work experience may have developed appropriate ways to handle challenges in their work plans regarding sleep and recovery, airline crew members suffering from severe sleep problems due to the irregular work hours have probably quit this type of work.

In the final analyses, we adjusted for sex, age, and BMI. Generally, while HRV is observed to be lower in women under age 30 compared to men, sex differences gradually disappear between age 30 and age 50. In the present study however, sex did not seem to influence any of the HRV parameters. With regard to age, older subjects had an overall lower HRV, in line with earlier research.[36] The quite high mean age of the subjects in the present study, reflects the age distribution among flight personnel in the company, which is partly a result of several periods of hiring freeze after the turn of the century. The observed decreased HRV by increasing BMI, is in accordance with results from previous studies.[19] Previous studies have shown that smoking disrupts the normal ANS functioning, characterized by increased sympathetic drive and reduced HRV, and parasympathetic modulation.[10] There were two smokers among the subjects. We performed analyses with and without the smokers, and as only minor differences between smokers and non-smokers were observed, we decided to keep the smokers in the final analysed dataset. In the present study, the impact of physical activity could not be evaluated, as all subjects reported a medium to high level of physical activity.

The strengths of the present study, include the use of a crossover design that eliminates uncontrolled confounding by use of an external control group.[27] Furthermore, the study was conducted in a real-life situation in which we had detailed exposure information, and information of other factors related to work and leisure time, which may potentially influence HRV parameters. [31] One limitation of the study is the small sample size, particularly the small pilot group, which reduces statistical power and thus the capacity to detect differences and trends observed at a borderline statistical significance. This was partly modified by the repeated-measurement design. Furthermore, the study population was not a random sample, which may have resulted in selection bias, and decrease the generalizability of the results. The skewed gender distribution within the two professions is however, similar to the actual distribution within the group of cabin crew members and pilots in most airlines. Finally, although though the number of work hours was similar among all subjects, the exact times for check-in and check-out for duty varied, which may also have influenced the results.

The findings of this study supports the contention that a work period consisting of minimum 39 working hours during four days, increases cardiac strain among cabin crew members and pilots. Higher cardiovascular strain was observed on the 4th versus the 1st day of flight duty, most prominent in the cabin crew members. Analyses of HRV during the nights, indicate a satisfactory recovery after the first and the fourth work day in both professional groups. Among the pilots, high demands were associated with increased cardiovascular strain during the entire work period. Among the cabin crew members, increased duration of sleep before, and breaks during the workdays, reduced cardiovascular strain. Further research is required to disentangle the complex interplay between predictors of cardiovascular health, such as work hours, work content, breaks, sleep, and factors related to organisational work environment.

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Table I Subject characteristics (N=59)

	Pilots (N=17*)	Cabin crew members (N=41)
Men	15	6
Women	2	35
Current smoker	1	1
Age	52 (SD 12.3)	40 (SD 7.4)
Body Mass Index (kg/m^2)	25 (SD 2.8)	24 (SD 3.6)
Reported sleep disturbances last year	9 (50%)	21 (51%)
Reported sleep disturbances last month	5 (27%)	12 (12%)
Work experience (in years)	26 (SD 7.7)	17 (SD 11.4)
Commuting time – one way (in minutes)	70	57
Physical activity (1-3 hours per week)	11 (65%)	24 (59%)
Physical activity (>3 hours per week)	6 (35%)	17 (41%)
Reported work/family conflict	7 (39%)	18 (44%)
Content with work pattern	8 (44%)	27 (66%)
Reported high workload quite often/always	11 (62%)	12 (31%)
Control over important decisions never/seldom	8 (44%)	22 (56%)

*Questionnaires were returned by 17 of 18 pilots

Table II Description of the selected Heart Rate Variability measures

HRV parameter (unit)	Description and interpretation
Mean RR interval (ms)	Mean of selected beat to beat (RR) interval series inversely proportional to HR.
RMSSD (ms)	Square root of the mean squared differences between successive RR intervals. RMSSD evaluates differences between successive RR intervals and reflects short-term variations. Low value indicates high cardiovascular strain.
HF powers (ms^2)	High-frequency power (range 0.15-0.4 Hz). High HF indicates low cardiovascular strain.
SDNN (ms)	Standard deviation of normal heart beat intervals. Estimates overall HRV, not distinguishing between changes due to reduced vagal tone or increased sympathetic activity. Low value indicates high cardiovascular strain.
LF power (ms^2)	Low frequency power (range 0.04-0.15 Hz). High LF may indicate high cardiovascular strain.
LF/HF ratio	The selected frequency-domain parameter is the ratio between low frequency and high frequency power components. The LF/HF ratio estimates sympatho-vagal balance. High LF/HF indicates high cardiovascular strain

Table III Reported information from the work/sleep diaries

	Cabin crew members		Pilots	
	Day 1 (N=41)	Day 4 (N=26)	Day 1 (N=18)	Day 4 (N=16)
Mean hours of sleep the previous night (range, hours)	6 (4-8)	7 (4-8)	7 (4.5-8)	7 (4.5-10)
No. of subjects reporting ≥ 30 minutes before falling asleep	16 (39%)	4 (10%)	5 (28%)	1 (6%)
No. of subjects reporting ≥ 30 minutes awake in between sleep	13 (32%)	7 (17%)	3 (17%)	3 (17%)
No. of subjects reporting awakening ≥30 minutes before planned	16 (39%)	14 (34%)	5 (28%)	4 (22%)
Mean check-in times AM (SD)	7:45(2.0)	9:19 (2.6)	8:13 (2.5)	10:2 (3.3)
Mean duty hours (SD)	11.2 (1.1)	10.6 (1.8)	10.9 (1.3)	10.1 (1.6)
Mean no. of flight sectors (range)	3.8 (2-6)	3.5 (2-5)	3.4 (2-6)	3.9 (3-5)

Table IV Changes in mean RR, RMSSD, SDNN and LF/HF between workday 4 and 1, for different time segments, among cabin crew members and pilots.

	Cabin crew members (N=35)				Pilots (N=12)			
	Mean RR	RMSSD	SDNN	LFHF	Mean RR	RMSSD	SDNN	LFHF
Hours	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
0-3	**29.4 (13.8,45.0)**	3.3 (-0.2, 6.7)	-1.0 (-5.1, 3.2)	0.0 (-0.5, 0.5)	**-48.7 (-82.9,-14.5)**	-2.7 (-7.4, 1.9)	-3.2 (-7.5, 1.1)	-0.2 (-1.0, 0.6)
4-7	**14.3 (0.2, 28.3)**	-1.6 (-4.8, 1.5)	**-4.9 (-8.7,-1.1)**	**0.5 (0.1, 1.0)**	-24.4 (-54.8, 6.1)	-0.6 (-4.7, 3.6)	-1.4 (-5.2, 2.4)	-0.2 (-1.0, 0.5)
8+	-11.3 (-26.2, 3.7)	-3.2 (-6.5, 0.1)	**-5.2 (-9.2,-1.2)**	**0.6 (0.1, 1.1)**	**-37.0 (-72.4, -1.7)**	-1.6 (-6.4, 3.2)	-2.4 (-6.8, 2.1)	0.3 (-0.5, 1.2)

B (95% CI): estimate of difference between Day 4 and Day 1 (Day 4 – Day 1) with 95% confidence interval, adjusted for gender, age and BMI.
Bold numbers indicate significant values

Table V Changes in mean RR, RMSSD, SDNN and LF/HF between the baseline night (night 0) and the nights 1, 4 and 6 respectively, for each of the first four hours of sleep and the hour of wake-up, among cabin crew members and pilots.

		Cabin crew members (N=41)				Pilots (N=17)			
		MeanRR	RMSSD	SDNN	LFHF	MeanRR	RMSSD	SDNN	LFHF
Night	Hours	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
1 vs 0	1hr sleep	0.1 (-32.9, 33.1)	1.6 (-4.3, 7.4)	0.6 (-4.2, 5.4)	-0.1 (-0.8, 0.7)	-30.4 (-85.6, 24.9)	-0.7 (-7.8, 6.4)	-0.5 (-8.5, 7.5)	-1.0 (-2.4, 0.3)
1 vs 0	2hr sleep	-16.2 (-48.9, 16.6)	0.0 (-5.9, 5.8)	-1.1 (-5.9, 3.7)	-0.3 (-1.1, 0.4)	-9.0 (-64.1, 46.1)	1.8 (-5.3, 8.9)	-0.5 (-8.5, 7.4)	**-1.9 (-3.2, -0.6)**
1 vs 0	3hr sleep	-12.3 (-45.0, 20.5)	-2.9 (-8.7, 2.9)	-4.6 (-9.4, 0.2)	0.1 (-0.7, 0.8)	-12.4 (-69.4, 44.6)	-0.8 (-8.1, 6.6)	-4.2 (-12.5, 4.0)	**-2.5 (-3.8, -1.1)**
1 vs 0	4hr sleep	-12.3 (-45.3, 20.7)	-3.3 (-9.2, 2.5)	-3.0 (-7.8, 1.8)	0.2 (-0.5, 1.0)	-20.9 (-79.1, 37.4)	-4.1 (-11.6, 3.4)	-5.6 (-14.0, 2.9)	-0.7 (-2.1, 0.7)
1 vs 0	wake-up	**143.3 (91.9,194.8)**	4.0 (-5.2, 13.1)	-2.1 (-9.6, 5.4)	**-1.5 (-2.7, -0.3)**	**118.6 (20.8,216.3)**	6.3 (-6.3, 18.9)	9.4 (-4.8, 23.5)	-2.0 (-4.3, 0.4)
4 vs 0	1hr sleep	17.6 (-20.9, 56.0)	3.9 (-2.9, 10.8)	2.8 (-2.8, 8.4)	-0.2 (-1.1, 0.6)	4.0 (-56.7, 64.7)	3.9 (-4.0, 11.7)	4.2 (-4.6, 13.0)	-0.9 (-2.4, 0.6)
4 vs 0	2hr sleep	-14.3 (-52.7, 24.2)	0.3 (-6.5, 7.2)	0.0 (-5.6, 5.6)	0.3 (-0.6, 1.2)	25.0 (-35.0, 84.9)	6.4 (-1.3, 14.2)	3.0 (-5.7, 11.7)	**-1.9 (-3.3, -0.4)**
4 vs 0	3hr sleep	-10.4 (-48.8, 28.0)	2.8 (-4.0, 9.6)	2.2 (-3.4, 7.8)	0.4 (-0.5, 1.3)	9.8 (-53.6, 73.2)	5.4 (-2.8, 13.6)	4.9 (-4.3, 14.0)	-1.6 (-3.1, 0.0)
4 vs 0	4hr sleep	-0.8 (-39.3, 37.6)	1.9 (-4.9, 8.8)	1.5 (-4.1, 7.1)	0.0 (-0.9, 0.9)	-21.5 (-84.6, 41.6)	-1.5 (-9.7, 6.6)	-3.1 (-12.2, 6.0)	-0.8 (-2.4, 0.7)
4 vs 0	wake-up	**185.8 (124.4,247.2)**	6.7 (-4.2, 17.6)	-0.6 (-9.6, 8.3)	**-2.1 (-3.5, -0.7)**	**212.6 (115.3,310.0)**	3.9 (-8.7, 16.4)	4.8 (-9.3, 18.9)	-1.6 (-3.9, 0.8)
6 vs 0	1hr sleep	14.9 (-26.6, 56.5)	0.1 (-7.3, 7.5)	-1.9 (-8.0, 4.2)	-0.1 (-1.1, 0.8)	29.0 (-37.9, 95.9)	1.2 (-7.4, 9.8)	1.1 (-8.6, 10.8)	-1.1 (-2.8, 0.5)
6 vs 0	2hr sleep	-18.4 (-60.9, 24.1)	-4.5 (-12.0, 3.0)	-4.9 (-11.1, 1.2)	-0.3 (-1.3, 0.7)	57.5 (-8.3,123.3)	4.7 (-3.7, 13.2)	3.0 (-6.5, 12.5)	**-1.7 (-3.3, -0.1)**
6 vs 0	3hr sleep	-12.7 (-55.6, 30.3)	-1.0 (-8.7, 6.6)	-0.8 (-7.0, 5.5)	0.3 (-0.7, 1.3)	44.0 (-29.5,117.5)	**12.2 (2.7, 21.6)**	8.5 (-2.1, 19.1)	**-1.9 (-3.7, -0.1)**
6 vs 0	4hr sleep	6.2 (-36.8, 49.2)	-1.8 (-9.4, 5.9)	-2.7 (-8.9, 3.6)	0.0 (-1.0, 1.0)	1.0 (-67.7, 69.8)	-0.1 (-9.0, 8.7)	-1.1 (-11.1, 8.8)	0.2 (-1.4, 1.9)
6 vs 0	wake-up	**244.5 (179.0,309.9)**	**16.9 (5.2, 28.5)**	8.1 (-1.5, 17.6)	**-3.1 (-4.6, -1.6)**	**282.2 (174.1,390.3)**	4.5 (-9.4, 18.5)	6.3 (-9.4, 21.9)	-1.1 (-3.7, 1.5)

B (95% CI): estimate of difference between Night 1, 4, 6 and Night 0 (Night 1- Night 0, Night 4 - Night 0, Night 6 - Night 0) with 95% confidence interval adjusted for gender, age and BMI.
Bold numbers indicate significant values

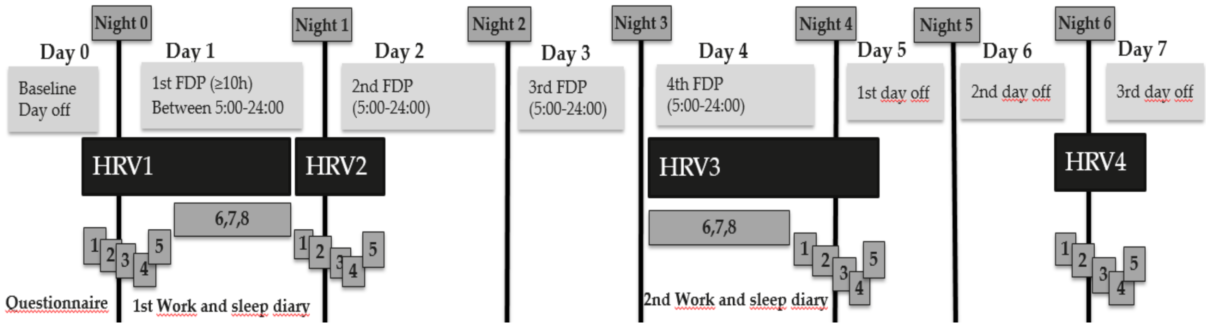

Figure 1. Flowchart of the data collection

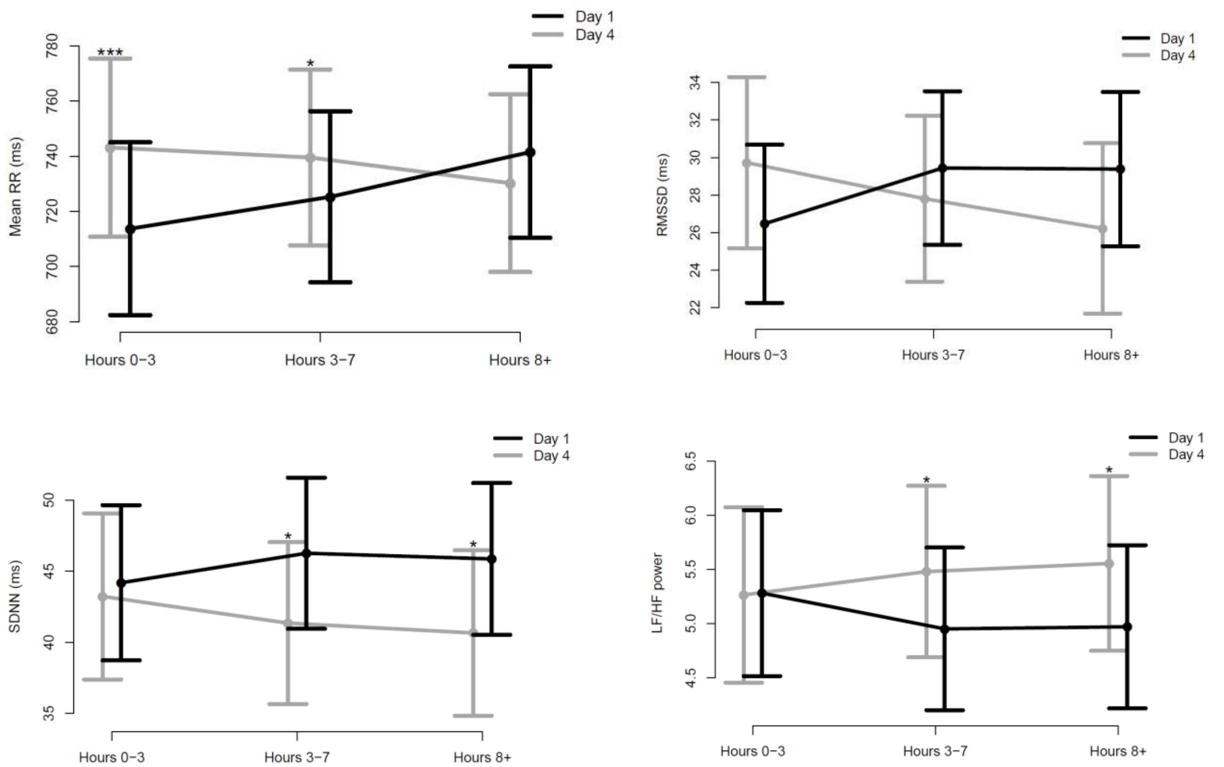

Figure 2. RR, RMSSD, SDNN, LF/HF on workday 4 versus workday 1 among cabin crew members

Vil du som er kabinansatt eller pilot i SAS delta i en studie av hvordan lange arbeidsdager/komprimerte arbeidsblokker virker på sikkerhet og helse?

Flere studier viser at skift- og nattarbeid innebærer økt risiko for både uheldige hendelser og hjerte/karsykdommer. Imidlertid er det en betydelig mangel på kunnskap relatert til mulig risiko for negative helseeffekter knyttet til lange arbeidsdager eller komprimerte arbeidsblokker.

Lange arbeidsdager kan være spesielt belastende dersom det ikke er tilstrekkelig tid til hvile mellom arbeidsperiodene, siden søvnmangel over flere påfølgende dager kan føre til kumulativ fatigue.

Hvis du deltar i studien vil du bli bedt om å gjennomføre to oppmerksomhetstester (PC-tester), i tillegg til å måle din hjerterytmevariabilitet (HRV) ved hjelp av pulsmåler.

Oppmerksomhetstestene skal gjennomføres både etter en periode med fridager, og etter første og siste arbeidsdag i en slinge.

Målinger av hjerterytmevariabilitet vil finne sted fra kvelden før første arbeidsdag i slingen til morgenen etter første arbeidsdag, samt fra morgenen siste arbeidsdag til morgenen første fridag etter avsluttet siste arbeidsdag.

Du vil også bli bedt om å fylle ut et spørreskjema med bakgrunnsinformasjon, og føre loggbok over aktiviteter, inntak av mat, kaffe, nikotin, hvilepauser etc i løpet av første og siste arbeidsdag i slingen.

Deltakerne fungerer som sine egne kontroller. Døgnmålinger av hjerterytme, resultat fra årvåkenhetstester og spørreskjemadata vil bli analysert i samarbeid med forskere fra Finland og Japan.

Vårt forskningsprosjekt vil kunne gi en nyttig kunnskapsplattform for planlegging av helsefremmende og sikre rostere.

Vi vil informere nærmere om studien på en stand på crewbasen om kort tid. Der vil du også kunne melde deg som deltaker.

Du kan også få informasjon og melde deg som deltaker via e-post eller telefon.

Hilsen

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UiO : Institutt for helse og samfunn
Det medisinske fakultet

UNIVERSITY OF EASTERN FINLAND

Statens arbeidsmiljøinstitutt

Forespørsel om deltakelse i forskningsprosjektet

Er komprimert arbeidstid/lange arbeidsøkter en risikofaktor for arbeidsulykker og hjertekarsykdom?

Bakgrunn og hensikt
Dette er et spørsmål til deg om å delta i en forskningsstudie for å undersøke sammenhengen mellom komprimert arbeidstid og lange arbeidsøkter og risiko for arbeidsulykker og hjertekarsykdom.

Hva innebærer studien?
Din deltakelse i studien vil pågå i løpet av én arbeidsblokk med flere lange arbeidsdager i strekk. Først ber vi deg fylle ut et spørreskjema ang arbeidstidsordning, reisevei, livsstil søvn og helseplager. Vi vil deretter foreta to oppmerksomhetstester med bruk av en PC. Disse testene må gjøres på en fridag (beregnet tidsforbruk ca en time), og deretter etter første arbeidsdag (en halv time), og etter siste dag i arbeidsblokken (en halv time). Det blir målt hjerterytmevariabilitet over 2 eller flere døgnperioder ved hjelp av en pulsklokke som du har festet på brystet. Undersøkelsen innebærer også føring av en logg (dagbok) for å få en oversikt over "hendelser" i forhold til arbeidets utførelse som antas å kunne føre til eller avhjelpe fatigue, helse- og sikkerhetsrisiko, f.eks fysisk tungt arbeid, stress og hvileperioder under arbeidsdagen.

Mulige fordeler og ulemper
Undersøkelsene innebærer ingen ubehagelige eller risikofylte aktiviteter. Du gjør ditt vanlige arbeid og gir prosjektet informasjon om hva du gjør i løpet av arbeidsskiftene. Til oppmerksomhetstestene trenger du dine vanlige briller som du leser med, dersom du bruker briller. Studien har som mål å gi kunnskap om effekter av lange og komprimerte arbeidsøkter/arbeidsplaner, og slik kunnskap er nyttig når man skal planlegge turnussystemer eller angi tiltak mot uheldige effekter av enkelte arbeidstidsordninger

Hva skjer med informasjonen om deg?
Informasjonen fra undersøkelsen vil bli lagret på datamaskin og bearbeidet statistisk for å måle størrelsen på eventuelle sammenhenger mellom komprimert arbeidstid og ulykkesrisiko og hjerterytmevariabilitet. All identifiserende informasjon (inkludert navnelisten) blir slettet når studien er ferdig, og senest 1/1-2018.
Det vil ikke være mulig å identifisere deg i analysefiler eller i resultatene av studien når disse publiseres.

Frivillig deltakelse
Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dette vil ikke få konsekvenser for din videre behandling. Dersom du ønsker å delta, undertegner du vedlagte samtykkeerklæring. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling. Dersom du senere ønsker å trekke deg eller har spørsmål til studien, kan du kontakte prosjektleder Jenny-Anne Sigstad Lie, Statens arbeidsmiljøinstitutt, telefonnr 23195100

Ytterligere informasjon om studien finnes i kapittel *A* – *utdypende forklaring av hva studien innebærer.* **Ytterligere informasjon om personvernforhold finnes i kapittel *A***

Ytterligere informasjon om personvern og forsikring finnes i kapittel B – *Personvern, biobank, økonomi og forsikring.*

Kapittel A- utdypende forklaring av hva studien innebærer

- Kriterier for deltakelse. Arbeidtakere med slik arbeidstidsordning som denne studien tar sikte på å studere, og som det er praktisk mulig å få gjort registreringer og tester til rett tid på døgnet av (undersøkelsen på fridag må gjøres på tilsvarende tid av døgnet som det undersøkelsen etter siste arbeidsøkt som blir studert gjøres). Videre må de som blir deltakere ikke ha sykdommer eller bruke medisiner som påvirker testene og pulsregistreringene, for eksempel enkelte typer hjertesykdom, søvnforstyrrelsessykdommer (søvnapne, bruk av sovetabletter), bruk av sterke smertestillende eller beroligende tabletter i undersøkelsesperioden.
- Vi inviterer fire grupper arbeidstakere med lange arbeidsskift/komprimert arbeidstid til å delta. Målet er å inkludere 30 arbeidstakere i hver gruppe:
    - Sykehjemsansatte
    - Kabinansatte
    - Piloter
    - Anleggsarbeidere
- Studien er et vitenskapelig samarbeid mellom Statens arbeidsmiljøinstitutt (STAMI), Flymedisinsk institutt, Universitetet i Oslo, universitetet i Kuopio, Finland og Jikei Institute, Osaka, Japan.
- Studien innebærer for det første to PC-baserte oppmerksomhetstester. Disse består av to ulike tester der du ved å trykke på visse taster på en enhet skal gi respons så hurtig og korrekt som mulig ut fra hva som vises på skjermen. Testene analyseres på en måte som gir informasjon om risikomomenter når det gjelder hurtighet og nøyaktighet på responsene, og hvilken påvirkning arbeidsskiftet har hatt på disse.
- For det andre innebærer studien å bære en pulsklokke som festes på brystet, gjennom 2-3 dager. Denne registerer aktivitet og hjerterytme. Variabiliteten av hjerterytmen er et uttrykk for hvordan hjertet påvirkes av stress og hvile.
- Tidsskjema. Vi starter opp studien høst 2014/vinter 2015, med å undersøke de som har gitt samtykke til deltakelse. Selve datainnsamlingen vil gå over få uker for hver gruppe.
- Mulige fordeler. Informasjon om forholdet mellom arbeid, arbeidsbelastning, stress og hvile på den ene siden, og ulykkesrisiko og risiko for hjerte-karsykdom på den andre siden er sterkt ønsket av samfunnet. Arbeidsmiljøloven er allerede basert på en rekke studier av forholdet mellom eksponering i arbeid og helseutfall. På arbeidstidsområdet er det en mangel på gode studier som kan gi svar på hvilke arbeidstidsordninger som er gode og hvilke som er mindre gode i forhold til å gi minst mulig helserisiko og mest mulig positive helseeffekter av arbeidet.
- Mulige bivirkninger. Festingen av pulsklokkesensorene skjer med små selvklebende pads. Det er mulig at noen deltakere kan få hudkløe eller annen reaksjon på klebestedet. Øvrige mulig bivirkninger av aktivitetene i studien er ikke forventet.
- Mulige ubehag/ulemper. Studien innebærer ikke ubehag for deltakerne. Det vil medgå noe tid til utfylling av skjemaer, logg over arbeidsaktiviteter og hvile gjennom arbeidsskiftene, påsetting og avtaking av pulsklokkene, og til å gjøre PC- testene.
- Hvis det ved undersøkelsene påvises mulig sykdom, vil den det gjelder bli fulgt opp med henvisning til fastlege eller spesialisthelsetjenesten. Resultatene fra hjerterytmeundersøkelsen overføres til bedriftshelsetjenesten (BHT) hvis den enkelte samtykker til dette.
- Studiedeltakerens påtar seg intet ansvar overfor studien ved å delta.
- Studiedeltakerne vil få informasjon om resultatene fra studien i form av et informasjonsbrev som vi sender til hver av de deltakende institusjoner/firmaer når resultatene er blitt publisert. Dersom det skulle komme informasjon som kan påvirke deltakerens villighet til å delta i studien, vil vi på samme måte frembringe informasjon om dette uten opphør.
- Eventuell kompensasjon til og dekning av utgifter for deltakere: prosjektet har ikke avsatt midler til å honorere deltakerne for selve deltakelsen.

Kapittel B - Personvern, økonomi og forsikring

Personvern
Opplysninger som registreres om deg er:
Fødselsdato, ansettelsesperiode/dato, dato og tid for aktuelle skift, tobakksbruk, kaffeinntak, matinntak, søvn og hvile generelt og relatert til datainnsamlingsperioden du er med i. Videre fører du en logg for hver dag de dagene du deltar, der du spesifiserer en rekke forhold relatert til arbeidet, arbeidets utførelse og hvileperioder. Dataene blir lagt inn i en PC og behandlet statistisk, og uavhengig av navn, fødselsedato, telefonnummer og andre direkte identifiserende data (som vi vil oppbevare separat og knytte til forskningsdataene gjennom et ikke-informativt løpenummer). Dette løpenummeret sikrer bl.a. at man skal kunne slette personer som senere ønsker å trekke seg fra studien hvis aktuelt.

Alle opplysningene og prøvene vil bli behandlet uten navn og fødselsnummer eller andre identifiserende opplysninger. En kode knytter deg til dine opplysninger og prøver gjennom en navneliste. Navnelisten blir ikke oppbevart sammen med forskningsdataene, men slettes fra PC-en unntatt i forbindelse med selve datainnsamlingsdagene. Deretter oppbevares listen i eget avlåst rom. Det er kun autorisert personell knyttet til prosjektet som har adgang til navnelisten og som kan finne tilbake til deg. Kun de vitenskapelig ansvarlige for studien vil kunne se dataene, og alle som får innsyn har taushetsplikt. STAMI ved direktøren er databehandlingsansvarlig.

Rett til innsyn og sletting av opplysninger om deg
Hvis du sier ja til å delta i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert om deg. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra studien, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede inngår i analyser eller er brukt i vitenskapelige publikasjoner. Etter at koden er slettet (når all publisering er foretatt), er sletting av data for enkeltpersoner ikke lengre mulig.

Økonomi
Vi søker om driftsmidler og ev tilskudd til lønnsmidler fra LO, Nasjonalforeningen for Folkehelsen og den Internasjonale Transportarbeiderføderasjonen (ITF). Økonomiske bidragsytere ellers er de deltakende institusjonene (STAMI, Flymedisinsk institutt, Universitetet i Oslo (Avdeling for helse og samfunn), Universitetet i Kuopio, Finland, og Jikei Institute, Osaka, Japan). Eksterne bidragsytere har ikke hatt innvirkning på utbeidelse av studien eller dens aktiviteter, og vil ikke kunne påvirke publisering av resultatene.

Forsikring
Studien innebærer ikke andre aktiviteter enn ditt vanlige arbeid, så spesielle forsikringer ut over det som gjelder din vanlige yrkesdeltakelse og som dekkes gjennom arbeidsgiver vil ikke bli tegnet.

Informasjon om utfallet av studien
Deltakerne vil motta et informasjonsbrev om studien gjennom arbeidsgiver når resultatene er publisert. Det vil også bli lagt ut informasjon om studien og om resultater, når disse foreligger, på STAMIs hjemmeside www.stami.no

Skjema for samtykke ligger ved dette informasjonsskrivet.

Samtykke til deltakelse i studien
Er komprimert arbeidstid/lange arbeidsøkter en risikofaktor for arbeidsulykker og hjertekarsykdom?

Jeg er villig til å delta i studien

(Navn med blokkbokstaver)

(Signatur prosjektdeltaker, dato)

Tlf/ Mobilnummer:________________________

Fylles ut av forskerne:

Id-nummer: _______________

Jeg bekrefter å ha gitt informasjon om studien

(Signert, rolle i studien, dato)

ID-nr:________________

Spørreskjema for ansatte ved Vea Sykehjem

GENERELLE SPØRSMÅL

1. **Dagens dato**: ____________________________

2. **Hva er ditt fødselsår?** ☐☐☐☐

3. **Sivilstand?**

Gift, Samboer	❑
Enslig	❑

4. **Hvor mange barn under 18 år bor sammen med deg (hele eller deler av tiden)?** ☐

5. **Hva er din offisielle yrkestittel? (Kryss av for den tittelen som passer best)**

Sykepleier	❑
Helsefagarbeider	❑
Vernepleier	❑
Miljøterapeut	❑
Annet	❑

ARBEID

6. **Hvor lenge har du hatt denne stillingen?** ☐☐ år

7. **Jobber du full stilling?**
   - ❑ Ja, 100%
   - ❑ Nei. **Hvor mange prosent utgjør din stilling**? ☐☐ prosent

8. **Hvor lang tid bruker du fra du går hjemmefra til du er på jobben?** ☐☐☐ minutter

9. **<u>Hvor mange pauser</u> kan du vanligvis ta i løpet av et skift? Antall:** ☐☐

ID-nr:_______________

10. Kan du selv påvirke når du skal jobbe, eller hvor lange skift du skal arbeide?

- ❑ Ja
- ❑ Nei

11. Vet du på forhånd skiftplanen din, eller hvor lange skift du skal arbeide?

- ❑ Ja
- ❑ Nei

12. Er du fornøyd med din skiftordning?

- ❑ Ja
- ❑ Nei

13. Hvor ofte blir du bedt om å arbeide andre skift enn det som var planlagt?

Inntil 1 dag /uke ☐ Inntil 2 dager/mnd ☐ 1 dag /mnd eller sjeldnere ☐ Aldri ☐

14. Har du for mye å gjøre? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

15. Kan du selv bestemme ditt arbeidstempo? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

16. Kan du påvirke beslutninger som er viktige for ditt arbeid? Meget sjelden eller aldri ☐

Nokså sjelden ☐ Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

17. Opplever du balanse mellom hjem og arbeid som vanskelig i nåværende situasjon?

Ja ☐ Nei ☐

ID-nr:________________

SØVN

18. I tabellen under er det 6 spørsmål knyttet til søvn og tretthet. Vær vennlig å kryss av for det alternativet (antall dager per uke) som passer best for deg. 0 svarer til ingen dager i løpet av en uke, 7 til alle dager i uka.

	Antall dager per uke							
	0	1	2	3	4	5	6	7
a) I løpet av den siste måneden, hvor mange ganger per uke har du brukt mer enn 30 minutter for å sovne inn etter at lysene ble slukket?	❑	❑	❑	❑	❑	❑	❑	❑
b) I løpet av den siste måneden, hvor mange dager per uke har du vært våken mer enn 30 minutter innimellom søvnen?	❑	❑	❑	❑	❑	❑	❑	❑
c) I løpet av den siste måneden, hvor mange dager per uke har du våknet mer enn 30 minutter tidligere enn du har ønsket, uten å få sove igjen?	❑	❑	❑	❑	❑	❑	❑	❑
d) I løpet av den siste måneden, hvor mange dager per uke har du følt deg for lite uthvilt etter å ha sovet?	❑	❑	❑	❑	❑	❑	❑	❑
e) I løpet av den siste måneden, hvor mange dager per uke har du vært så søvnig/trett at det har gått utover skole/jobb eller privatlivet?	❑	❑	❑	❑	❑	❑	❑	❑
f) I løpet av den siste måneden, hvor mange dager per uke har du vært misfornøyd med søvnen din?	❑	❑	❑	❑	❑	❑	❑	❑

19. Hvis du skal beskrive deg selv i forhold til din døgnrytme, er du

❑ Typisk A-menneske (morgenfugl, trett om kvelden)

❑ Typisk B-menneske (opplagt om kvelden, trøtt om morgenen)

❑ Verken typisk A- eller typisk B-menneske

20. Røyker du daglig?

❑ Ja

❑ Nei

21. Har du tidligere røykt?

❑ Ja

❑ Nei

22. Hvis du har røykt tidligere, angi årstall for røykeslutt: ☐☐☐☐

23. Hvor mange år har du røykt daglig? ____________________

ID-nr:_________________

FYSISK AKTIVITET OG MOSJON

24. a) Hvordan har din fysiske aktivitet i fritiden vært det siste året? *Arbeidsvei regnes som fritid.*

	Timer per uke i gjennomsnitt			
	Ingen	Under 1	1-2	3 eller mer
Lett aktivitet (*ikke svett/andpusten)*	❑	❑	❑	❑
Hard fysisk aktivitet (*svett/andpusten)*	❑	❑	❑	❑

HELSEPROBLEMER

24. Nedenfor ber vi deg krysse av for helseplager som kan være forårsaket eller forverret av arbeidet ditt, OG som du har hatt i løpet av de siste 12 måneder, og i løp av de siste 4 uker.

	Siste 12 mnd	Siste fire uker
Smerter i nakken, skuldre eller øvre del av ryggen	❑	❑
Smerter i nedre del av ryggen	❑	❑
Smerter i armer, håndledd eller hender	❑	❑
Hodepine eller migrene	❑	❑
Tinnitus (øresus)	❑	❑
Stress	❑	❑
Søvnproblemer	❑	❑
Anstrengte øyne	❑	❑
Hjerte- eller karlidelser	❑	❑
Luftveisinfeksjoner, bilhulebetennelse o.l.	❑	❑
Sykdommer i lever, nyrer, fordøyelsessystem	❑	❑

ID-nr:________________

SPØRRESKJEMA CABIN CREW SAS

GENERELLE SPØRSMÅL

1. **Dagens dato**: ____________________________

2. **Hva er ditt fødselsår?** ☐☐☐☐

3. **Sivilstand?**

Gift, Samboer	❑
Enslig	❑

4. **Hvor mange barn under 18 år bor sammen med deg (hele eller deler av tiden)?** ☐

5. **Hva er din offisielle yrkestittel? (Kryss av for den tittelen som passer best)**

Air Purser	❑
Air Hostess/Host	❑
Air Steward	❑

ARBEID

6. **Hvor lenge har du arbeidet som Cabin Crew?** ☐☐ år

7. **Jobber du full stilling?**
   - ❑ Ja, 100%
   - ❑ Nei.

   Hvor mange prosent utgjør din stilling? ☐☐ prosent

8. **Hvilken arbeidstidsordning har du?** Fast ☐ Variabel ☐

9. **Hvor lang tid bruker du fra du drar hjemmefra til du er på OSL?** ☐☐☐ minutter

ID-nr:________________

10. Kan du selv påvirke når du skal jobbe? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

11. Er du fornøyd med din arbeidstidsordning?

- ☐ Ja
- ☐ Nei

12. Hvor ofte opplever du å bli omdisponert? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

13. Har du for mye å gjøre? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

14. Kan du selv bestemme ditt arbeidstempo? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

15. Kan du påvirke beslutninger som er viktige for ditt arbeid? Meget sjelden eller aldri ☐

Nokså sjelden ☐ Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

16. Opplever du balanse mellom hjem og arbeid som vanskelig i nåværende situasjon?

Ja ☐ Nei ☐

ID-nr:__________________

SØVN

17. I tabellen under er det 6 spørsmål knyttet til søvn og tretthet. Vær vennlig å kryss av for det alternativet (antall dager per uke) som passer best for deg. 0 svarer til ingen dager i løpet av en uke, 7 til alle dager i uka.

I løpet av den siste måneden	Antall dager per uke							
	0	1	2	3	4	5	6	7
a) Hvor mange ganger per uke har du brukt mer enn 30 minutter for å sovne inn etter at lysene ble slukket?	❑	❑	❑	❑	❑	❑	❑	❑
b) -har du vært våken mer enn 30 minutter innimellom søvnen?	❑	❑	❑	❑	❑	❑	❑	❑
c) - har du våknet mer enn 30 minutter tidligere enn du har ønsket, uten å få sove igjen?	❑	❑	❑	❑	❑	❑	❑	❑
d) - har du følt deg for lite uthvilt etter å ha sovet?	❑	❑	❑	❑	❑	❑	❑	❑
e) - har du vært så søvnig/trett at det har gått utover skole/jobb eller privatlivet?	❑	❑	❑	❑	❑	❑	❑	❑
f) - har du vært misfornøyd med søvnen din?	❑	❑	❑	❑	❑	❑	❑	❑

18. Hvis du skal beskrive deg selv i forhold til din døgnrytme, er du

❑ Typisk A-menneske (morgenfugl, trett om kvelden)

❑ Typisk B-menneske (opplagt om kvelden, trøtt om morgenen)

❑ Verken typisk A- eller typisk B-menneske

RØYKING

19. Røyker du daglig?

❑ Ja

❑ Nei

20. Har du tidligere røykt?

❑ Ja

❑ Nei

21. Hvis du har røykt tidligere, angi årstall for røykeslutt: ☐☐☐☐

22. Hvor mange år har du røykt daglig? ______________________

ID-nr:__________________

FYSISK AKTIVITET OG MOSJON

23. Hvordan har din fysiske aktivitet i fritiden vært det siste året?.

	Timer per uke i gjennomsnitt			
	Ingen	Under 1	1-2	3 eller mer
Lett aktivitet (*ikke svett/andpusten)*	❑	❑	❑	❑
Hard fysisk aktivitet (*svett/andpusten)*	❑	❑	❑	❑

HELSEPROBLEMER

24. Nedenfor ber vi deg krysse av for helseplager som kan være forårsaket eller forverret av arbeidet ditt, som du har hatt i løpet av de siste 12 måneder, og i løpet av de siste 4 uker.

	Siste 12 mnd	Siste fire uker
Smerter i nakken, skuldre eller øvre del av ryggen	❑	❑
Smerter i nedre del av ryggen	❑	❑
Smerter i armer, håndledd eller hender	❑	❑
Hodepine eller migrene	❑	❑
Tinnitus (øresus)	❑	❑
Stress	❑	❑
Søvnproblemer	❑	❑
Anstrengte øyne	❑	❑
Hjerte- eller karlidelser	❑	❑
Luftveisinfeksjoner, bilhulebetennelse o.l.	❑	❑
Sykdommer i lever, nyrer, fordøyelsessystem	❑	❑

ID-nr:________________

SPØRRESKJEMA FLIGHT CREW SAS

GENERELLE SPØRSMÅL

1. **Dagens dato**: ____________________________

2. **Hva er ditt fødselsår?** ☐☐☐☐

3. **Sivilstand?**

Gift, Samboer	❑
Enslig	❑

4. **Hvor mange barn under 18 år bor sammen med deg (hele eller deler av tiden)?** ☐

5. **Hva er din offisielle yrkestittel? (Kryss av for den tittelen som passer best)**

Flight Captain	❑
Flight Officer	❑

ARBEID

6. **Hvor lenge har du arbeidet som Flight Crew?** ☐☐ år

7. **Jobber du full stilling?**

   ❑ Ja, 100%

   ❑ Nei.

   Hvor mange prosent utgjør din stilling? ☐☐ prosent

8. **Hvilken arbeidstidsordning har du?** Fast ☐ Variabel ☐

9. **Hvor lang tid bruker du fra du drar hjemmefra til du er på OSL?** ☐☐☐ minutter

ID-nr:________________

10. Kan du selv påvirke når du skal jobbe? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

11. Er du fornøyd med din arbeidstidsordning?

- ☐ Ja
- ☐ Nei

12. Hvor ofte opplever du å bli omdisponert? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

13. Har du for mye å gjøre? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

14. Kan du selv bestemme ditt arbeidstempo? Meget sjelden eller aldri ☐ Nokså sjelden ☐

Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

15. Kan du påvirke beslutninger som er viktige for ditt arbeid? Meget sjelden eller aldri ☐

Nokså sjelden ☐ Noen ganger ☐ Nokså ofte ☐ Meget ofte eller alltid ☐

16. Opplever du balanse mellom hjem og arbeid som vanskelig i nåværende situasjon?

Ja ☐ Nei ☐

ID-nr:__________________

SØVN

17. I tabellen under er det 6 spørsmål knyttet til søvn og tretthet. Vær vennlig å kryss av for det alternativet (antall dager per uke) som passer best for deg. 0 svarer til ingen dager i løpet av en uke, 7 til alle dager i uka.

I løpet av den siste måneden	**Antall dager per uke**							
	0	1	2	3	4	5	6	7
a) Hvor mange ganger per uke har du brukt mer enn 30 minutter for å sovne inn etter at lysene ble slukket?	❑	❑	❑	❑	❑	❑	❑	❑
b) - har du vært våken mer enn 30 minutter innimellom søvnen?	❑	❑	❑	❑	❑	❑	❑	❑
c) - har du våknet mer enn 30 minutter tidligere enn du har ønsket, uten å få sove igjen?	❑	❑	❑	❑	❑	❑	❑	❑
d) -har du følt deg for lite uthvilt etter å ha sovet?	❑	❑	❑	❑	❑	❑	❑	❑
e) - har du vært så søvnig/trett at det har gått utover skole/jobb eller privatlivet?	❑	❑	❑	❑	❑	❑	❑	❑
f) - har du vært misfornøyd med søvnen din?	❑	❑	❑	❑	❑	❑	❑	❑

18. Hvis du skal beskrive deg selv i forhold til din døgnrytme, er du

❑ Typisk A-menneske (morgenfugl, trett om kvelden)

❑ Typisk B-menneske (opplagt om kvelden, trøtt om morgenen)

❑ Verken typisk A- eller typisk B-menneske

RØYKING

19. Røyker du daglig?

❑ Ja

❑ Nei

20. Har du tidligere røykt?

❑ Ja

❑ Nei

21. Hvis du har røykt tidligere, angi årstall for røykeslutt: ☐☐☐☐

22. Hvor mange år har du røykt daglig? ______________________

FYSISK AKTIVITET OG MOSJON

23. Hvordan har din fysiske aktivitet i fritiden vært det siste året?.

	Timer per uke i gjennomsnitt			
	Ingen	Under 1	1-2	3 eller mer
Lett aktivitet (*ikke svett/andpusten)*	❑	❑	❑	❑
Hard fysisk aktivitet (*svett/andpusten)*	❑	❑	❑	❑

HELSEPROBLEMER

24. Nedenfor ber vi deg krysse av for helseplager som kan være forårsaket eller forverret av arbeidet ditt, som du har hatt i løpet av de siste 12 måneder, og i løpet av de siste 4 uker.

	Siste 12 mnd	Siste fire uker
Smerter i nakken, skuldre eller øvre del av ryggen	❑	❑
Smerter i nedre del av ryggen	❑	❑
Smerter i armer, håndledd eller hender	❑	❑
Hodepine eller migrene	❑	❑
Tinnitus (øresus)	❑	❑
Stress	❑	❑
Søvnproblemer	❑	❑
Anstrengte øyne	❑	❑
Hjerte- eller karlidelser	❑	❑
Luftveisinfeksjoner, bilhulebetennelse o.l.	❑	❑
Sykdommer i lever, nyrer, fordøyelsessystem	❑	❑

ID-nr______________________________

LOGGBOK- for ansatte ved Vea Sykehjem

(fylles ut etter første og etter fjerde arbeidsdag)

Dagens dato:____________________

Hvilket klokkeslett starter dagens vakt?______________________________

Hvor lang tid brukte du for å komme til arbeidsstedet i dag? ☐timer ☐☐ minutter

Hvor mange timer har du sovet natt til i dag?______________________________

Hva var klokken da du våknet?____________________

Brukte du mer enn 30 minutter for å sovne inn etter at lysene ble slukket? Ja ☐ Nei ☐

Har du vært våken mer enn 30 minutter innimellom perioder med søvn? Ja ☐ Nei ☐

Våknet du mer enn 30 minutter tidligere enn du ønsket uten å få sove igjen? Ja ☐ Nei ☐

Har du trent/drevet fysisk aktivitet siste døgn? Ja ☐ Nei ☐

Hvis ja, hvordan har din fysiske aktivitet vært?	Mindre enn 20 minutter	20-40 minutter	Mer enn 40 minutter
Lett aktivitet (*ikke svett/andpusten)*	❑	❑	❑
Hard fysisk aktivitet (*svett/andpusten)*	❑	❑	❑

ID-nr______________________________

Dagens arbeidsøkt:

Søvnighet i løpet av vakten:

1. Ved vaktens start:

Sirkel rundt det som best beskriver din tilstand.	1. Helt våken og klar 2. Livlig, oppmerksom, ikke helt optimal 3. OK, nokså opplagt 4. Litt trett, mindre enn opplagt 5. Middels trett, uopplagt 6. Veldig trett, konsentrasjon vanskelig 7. Helt utmattet

2. Etter 8 timer:

Sirkel rundt det som best beskriver din tilstand.	8. Helt våken og klar 9. Livlig, oppmerksom, ikke helt optimal 10. OK, nokså opplagt 11. Litt trett, mindre enn opplagt 12. Middels trett, uopplagt 13. Veldig trett, konsentrasjon vanskelig 14. Helt utmattet

3. Ved vaktens slutt:

Sirkel rundt det som best beskriver din tilstand.	15. Helt våken og klar 16. Livlig, oppmerksom, ikke helt optimal 17. OK, nokså opplagt 18. Litt trett, mindre enn opplagt 19. Middels trett, uopplagt 20. Veldig trett, konsentrasjon vanskelig 21. Helt utmattet

Hvor stort har ditt inntak av koffein vært i løpet av vakten?

Antall kopper kaffe :______________________________

Ca. klokkeslett for kaffe:______________________________

Antall glass cola/andre drikker med koffeininnhold :______________________________

Ca klokkeslett for cola el. lign:______________________________

ID-nr________________________

Tobakk i løpet av vakten : Ja ☐ Nei ☐

Hvis ja:

Antall sigaretter: ________________________

Ca klokkeslett for røyking:________________________

Antall snuslegg: ________________________

Ca klokkeslett for snus:________________________

Tidspunkt for pauser og mat:

Hvor mange pauser har du hatt i løpet av vakten ?________________________

Når tok du pauser?________________________

Varighet av hver av pausene (minutter):________________________

Når (ca) spiste du i løpet av vakten?________________________

Fysiske belastninger

Hvis tyngre fysisk arbeid i løpet av vakten, ca når var det? Kl.________________________

Bemanning:

Var det full bemanning under vakten? Ja ☐ Nei ☐

Hvis ikke, hva besto avviket av?________________________

____

Oppsummering av dagens vakt

Hvordan har arbeidsbelastningen generelt vært?

Som normalt ☐ Større enn normalt ☐ Mindre enn normalt ☐

Hvis belastningen har vært større enn normalt, kan du beskrive hvorfor?________________________

____

____

ID-nr____________________________

Hvilket klokkeslett var du ferdig med dagens vakt?________________________

Nedenfor ber vi deg krysse av for helseplager du har hatt i løpet av denne arbeidsperioden, og som kan være forårsaket eller forverret av arbeidet ditt.

	Ikke plaget	Litt plaget	Ganske plaget	Svært plaget
Smerter i nakken, skuldre eller øvre del av ryggen				
Smerter i nedre del av ryggen				
Smerter i armer, håndledd eller hender				
Hodepine eller migrene				
Tinnitus (øresus)				
Stress				
Søvnproblemer				
Anstrengte øyne				
Hjerte-karlidelser				
Luftvegsinfeksjoner, bihulebetennelse el. lign				
Sykdommer i lever, nyrer eller fordøyelsessystemet				

Måling av aktivitet og hjerterytmevariabilitet (HRV)

NB!

Sensoren aktiveres ved å holde den «røde» → knappen inne i 3-4 sek.

Den blinker grønt (puls) når den er aktivert

Advarsel:

Sensoren tåler litt svette, men MÅ tas av under dusjing, bading etc.

Ved spørsmål ring: Jenny-Anne S. Lie: 905 86 994, eller Elisabeth Goffeng: 416 03 997

ID-nr______________________________

LOGGBOK CABIN CREW SAS

(fylles ut etter første og etter fjerde arbeidsdag)

Dagens dato:___________________

Klokkeslett for innsjekk?_________________________

Er dagens flygning planlagt i roster? Ja ☐ Nei ☐

Hvis nei, er du utkalt på standby, blank dag eller har du solgt fridag? (kryss av det som passer)

Standby ☐ Blank dag ☐ FX ☐

Når våknet du i dag tidlig? _________ Når la du deg i går kveld? __________

Hvor mange timer har du sovet natt til i dag?__________________________

Hvor lang tid brukte du for å komme til OSL i dag? ☐timer ☐☐ minutter

Brukte du mer enn 30 minutter for å sovne inn etter at lysene ble slukket? Ja ☐ Nei ☐

Har du vært våken mer enn 30 minutter innimellom perioder med søvn? Ja ☐ Nei ☐

Våknet du mer enn 30 minutter tidligere enn du ønsket uten å få sove igjen? Ja ☐ Nei ☐

Har du trent/drevet fysisk aktivitet siste døgn? Ja ☐ Nei ☐

Hvis ja, hvordan har din fysiske aktivitet vært?	Mindre enn 20 minutter	20-40 minutter	Mer enn 40 minutter
Lett aktivitet (*ikke svett/andpusten)*	❑	❑	❑
Hard fysisk aktivitet (*svett/andpusten)*	❑	❑	❑

ID-nr___________________________________

Søvnighet i løpet av dagens flygninger:

1. Ved innsjekk:

Sirkel rundt det som best beskriver din tilstand.	1. Helt våken og klar 2. Livlig, oppmerksom, ikke helt optimal 3. OK, nokså opplagt 4. Litt trett, mindre enn opplagt 5. Middels trett, uopplagt 6. Veldig trett, konsentrasjon vanskelig 7. Helt utmattet

2. Etter 8 timer:

Sirkel rundt det som best beskriver din tilstand.	8. Helt våken og klar 9. Livlig, oppmerksom, ikke helt optimal 10. OK, nokså opplagt 11. Litt trett, mindre enn opplagt 12. Middels trett, uopplagt 13. Veldig trett, konsentrasjon vanskelig 14. Helt utmattet

3. Ved utsjekk:

Sirkel rundt det som best beskriver din tilstand.	15. Helt våken og klar 16. Livlig, oppmerksom, ikke helt optimal 17. OK, nokså opplagt 18. Litt trett, mindre enn opplagt 19. Middels trett, uopplagt 20. Veldig trett, konsentrasjon vanskelig 21. Helt utmattet

ID-nr____________________________

Hvor stort har ditt inntak av koffein vært i løpet av dagens flygninger?

Antall kopper kaffe :____

Ca. klokkeslett for kaffe:______________________________________

Antall glass cola/andre drikker med koffeininnhold :______________________

Ca klokkeslett for cola el. lign:____________________________________

Tobakk i løpet av dagen : Ja ☐ Nei ☐

Hvis ja:

Antall sigaretter: ____

Ca klokkeslett for røyking:_____________________________________

Antall snuslegg: ____

Ca klokkeslett for snus:______________________________________

Tidspunkt for pauser og mat:

Hvor mange pauser har du hatt i løpet av dagens program?______________________

Når hadde du pause(r) og hvor lang varighet hadde pausen(e)?____________________

Har du hatt mealstop i henhold til din roster? Ja ☐ Nei ☐

Hvis nei, hva besto avviket av?______________________________________

____

Kan du angi tidspunkt for matinntak i løpet av arbeidsdagen, om spising foregikk om bord (i luften eller på bakken) eller om mealstop ble avholdt utenfor flyet?__________________

____

Fysiske belastninger

Hvis du opplevde tung fysisk belastning i løpet av dagens flygninger, kan du angi ca tidspunkt for belastningen(e)____

ID-nr_______________________________

Avvik:

Ble du i løpet av dagens flygninger omdisponert i forhold til dagens roster? Ja ☐ Nei ☐ Hvis ja, kan du beskrive endringen?_______________________________

Har noen av dagens flygninger vært forsinket? Ja ☐ Nei ☐

Hvis ja, medførte det kortere turnaroundtider? Ja ☐ Nei ☐

Var utsjekk senere enn schedulert? Ja ☐ Nei ☐

Har det i løpet av dagens flygninger vært forhold som førte til at du skrev cabin safety report eller fatigue/hazard report? Ja ☐ Nei ☐

Hvis ja, kan du kort beskrive årsaken til rapportering?_______________________________

____

____

Bemanning:

Var det full bemanning på dagens flygninger? Ja ☐ Nei ☐

Hvis ikke, hva besto avviket av?_______________________________

Byttet du crew i løpet av dagen? Ja ☐ Nei ☐

Hvis ja, hvor mange ganger_______________

Oppsummering av dagens flygninger

Hvordan har arbeidsbelastningen generelt vært?

Som normalt ☐ Større enn normalt ☐ Mindre enn normalt ☐

Hvis belastningen har vært større enn normalt, kan du kort beskrive hvorfor?_______________________________

____

Hvilket klokkeslett sjekket du ut etter dagens flygninger?_______________________________

ID-nr_______________________________

Nedenfor ber vi deg krysse av for helseplager du har hatt i løpet av denne slingen, og som kan være forårsaket eller forverret av arbeidet ditt.

	Ikke plaget	Litt plaget	Ganske plaget	Svært plaget
Smerter i nakken, skuldre eller øvre del av ryggen				
Smerter i nedre del av ryggen				
Smerter i armer, håndledd eller hender				
Hodepine eller migrene				
Tinnitus (øresus)				
Stress				
Søvnproblemer				
Anstrengte øyne				
Hjerte-karlidelser				
Luftveisinfeksjoner, bihulebetennelse el. lign				
Sykdommer i lever, nyrer eller fordøyelsessystemet				

Måling av aktivitet og hjerterytmevariabilitet (HRV)

NB!

Sensoren aktiveres ved å holde den «røde» → knappen inne i 3-4 sek.

Den blinker grønt (puls) når den er aktivert

Advarsel:

Sensoren tåler litt svette, men MÅ tas av under dusjing, bading etc.

Ved spørsmål ring: Jenny-Anne S. Lie: 905 86 994, eller Elisabeth Goffeng: 416 03 997

ID-nr__________

LOGGBOK FLIGHT CREW SAS

(fylles ut etter første og etter femte arbeidsdag i slingen)

Dagens dato:______________________________

Klokkeslett for innsjekk _______________________

Er dagens flygning planlagt i roster? Ja ☐ Nei ☐

Hvis nei, er du utkalt på standby, blank dag eller har du solgt fridag? (kryss av det som passer)

Standby ☐ Blank dag ☐ FX ☐

Hvor lang tid brukte du for å komme til OSL i dag? ☐timer ☐☐ minutter

Hvor mange timer har du sovet natt til i dag? __________________

Brukte du mer enn 30 min for å sovne etter at lysene ble slukket i går kveld? Ja ☐ Nei

☐ Har du vært våken mer enn 30 minutter innimellom perioder med søvn? Ja ☐ Nei

☐ Våknet du mer enn 30 minutter tidligere enn du ønsket uten å få sove igjen? Ja ☐ Nei

☐ Har du trent/drevet fysisk aktivitet siste døgn? Ja ☐ Nei ☐

Hvis ja, hvordan har din fysiske aktivitet vært?	Mindre enn 20 minutter	20-40 minutter	Mer enn 40 minutter
Lett aktivitet *(ikke svett/andpusten)*	❑	❑	❑
Hard fysisk aktivitet *(svett/andpusten)*	❑	❑	❑

D-nr____________

Dagens flygninger:

Søvnighet i løpet av arbeidsdagen:

1. Ved innsjekk:

Sirkel rundt det som best beskriver din tilstand.	1. Helt våken og klar. 2. Livlig, oppmerksom, ikke helt optimal 3. OK, nokså opplagt 4. Litt trett, mindre enn opplagt 5. Middels trett, uopplagt 6. Veldig trett, konsentrasjon vanskelig 7. Helt utmattet

2. Etter 8 timer

Sirkel rundt det som best beskriver din tilstand.	8. Helt våken og klar. 9. Livlig, oppmerksom, ikke helt optimal 10. OK, nokså opplagt 11. Litt trett, mindre enn opplagt 12. Middels trett, uopplagt 13. Veldig trett, konsentrasjon vanskelig 14. Helt utmattet

3 Ved utsjekk

Sirkel rundt det som best beskriver din tilstand.	15. Helt våken og klar. 16. Livlig, oppmerksom, ikke helt optimal 17. OK, nokså opplagt 18. Litt trett, mindre enn opplagt 19. Middels trett, uopplagt 20. Veldig trett, konsentrasjon vanskelig 21. Helt utmattet

Hvor stort har ditt inntak av koffein vært i løpet av dagens flygninger?

Antall kopper kaffe :____

Ca. klokkeslett for kaffe:____

Antall glass cola/andre drikker med koffeininnhold :__________________________

Ca klokkeslett for cola el. lign:____

Tobakk i løpet av dagen : Ja ☐ Nei ☐

Hvis ja:

Antall sigaretter: ____

Ca klokkeslett for røyking:____

Antall snuslegg: ____

Ca klokkeslett for snus:____

Tidspunkt for pauser og mat:

Hvor mange pauser har du hatt i løpet av dagens program ?__________

Når tok du pauser, og hvor lang varighet hadde pausene?__________________________

Har du hatt mealstop i henhold til din roster? Ja ☐ Nei ☐

Hvis nei, hva besto avviket av?____

Kan du angi tidspunkt for matinntak i løpet av arbeidsdagen, om spising foregikk om bord (i luften eller på bakken) eller om mealstop ble avholdt utenfor flyet?__________________

____

Fysiske belastninger

Hvis du opplevde tunge fysisk belastninger i løpet av dagens flygninger, kan du angi tidspunkt?____

ID-nr______________

Avvik:

Ble du i løpet av dagens flygninger omdisponert i forhold til dagens roster? Ja ☐ Nei ☐

Hvis ja, kan du beskrive endringen?____

____

Har noen av dagens flygninger vært forsinket? Ja ☐ Nei

☐ Hvis ja, medførte det kortere turnaroundtider? Ja

☐ Nei ☐ Var utsjekk senere enn schedulert? Ja ☐ Nei

☐

Har det i løpet av dagens flygninger vært forhold som førte til at du skrev flight safety report, flight occurrence report eller fatigue/hazard report??

Ja ☐ Nei ☐

Hvis ja, kan du kort beskrive årsaken til rapportering?______________________________

____

____

Bemanning:

Byttet du crew i løpet av dagens program? Ja ☐ Nei ☐

Hvis ja, hvor mange ganger?____

Oppsummering av arbeidsdagen

Hvordan har arbeidsbelastningen vært på denne arbeidsdagen?

Som normalt ☐ Større enn normalt ☐ Mindre enn normalt ☐

Hvis belastningen har vært større enn normalt, kan du kort beskrive hvorfor?__________________

____

Hvilket klokkeslett sjekket du ut etter dagens flygninger?______________________________

ID-nr____________

Nedenfor ber vi deg krysse av for helseplager du har hatt i løpet av denne slingen, og som kan være forårsaket eller forverret av arbeidet ditt.

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Smerter i nedre del av ryggen				
Smerter i armer, håndledd eller hender				
Hodepine eller migrene				
Tinnitus (øresus)				
Stress				
Søvnproblemer				
Anstrengte øyne				
Hjerte-karlidelser				
Luftveisinfeksjoner, bihulebetennelse el. lign				
Sykdommer i lever, nyrer eller fordøyelsessystemet				

Måling av aktivitet og hjerterytmevariabilitet (HRV)

NB!

Sensoren aktiveres ved å holde den «røde» → knappen inne i 3-4 sek.

Den blinker grønt (puls) når den er aktivert

Advarsel:

Sensoren tåler litt svette, men MÅ tas av under dusjing, bading etc.

Ved spørmål ring: Jenny-Anne S. Lie: 905 86 994, eller Elisabeth Goffeng: 416 03 997

<u>Huskeliste ved baselinetesting</u>

Ta kontakt med den som skal testes på forhånd og avtal tidspunkt, og at hun/han ringer deg for å bli låst inn nede. Husk evt parkeringslapp!

1. PC rigges opp med lader, høretelefon (grønn kontakt inn på høyre side av pc), legg huskelapper for vannrett og loddrett på hver side (loddrett høyre side/vannrett venstre side), og legg instruksjon samt vurderingsskjema for vanskelighetsgrad/innsats klart.
2. Spør om de har lest info, elle om de trenger mer info om studien
3. Undertegning av samtykkeerklæring (signer med initialer og dato på journalforside)
4. Utfylling av spørreskjema (signer med initialer/dato på journalforside)
5. <u>Gå inn på Superlab</u>
    a. Gå inn på øvelse, start med "STAMI_digit_3_DemoPractice" og lagre i feltet "Participant Name" med en enkelt bokstav (dette gjøres i to etterfølgende vinduer, men skal ikke tas vare på i etterkant). Demonstrer testen, og la vedkommende øve seg noe. Lukk filen ved å trykke på q.
    b. Gå deretter inn på Superlab på nytt, og velg denne gang STAMI_Digit_3_Full test", trykk ok på første vindu som sier "this experiment file is older than this version of Superlab", trykk så på pilknappen for "run", skriv inn id-kode på feltet "participant name" eks. C09_SAR1. Et nytt vindu vises, og her skrives id-koden på nytt over blått felt merket Superlab Data File nede til venstre på vinduet. Trykk så på "Lagre".
    c. Når testen er ferdig, trykk på q for å avslutte.
    d. Gå inn på øvelse igjen, start med " STAMI_Diamond_Test_DemoPractice" og lagre i feltet "Participant Name" med en enkelt bokstav (dette gjøres også i to etterfølgende vinduer, men skal ikke tas vare på i etterkant). Demonstrer testen, og start deretter øvelsen på 8 miutter. Lukk filen ved å trykke på q.
    e. Gå deretter inn på Superlab på nytt, og velg denne gang STAMI_Diamond_Test_Full test", trykk ok på første vindu som sier "this experiment file is older than this version of Superlab", trykk så på pilknappen for "run", skriv inn id-kode på feltet "participant name" eks. C09_AC1. Et nytt vindu vises, og her skrives id-koden på nytt over blått felt merket Superlab Data File nede til venstre på vinduet. Trykk så på "Lagre".
    f. Når testen er ferdig, trykk på q for å avslutte.
6. Fyll ut tidspunkt, dato for de ulike testene på journalforside og signer når testene er gjennomført. Skriv nummer på pc som er anvendt i venstre marg.
7. <u>Lagring på minnepinne</u>
    a. Sett inn minnepennen på uttak på høyre side av PC.
    b. Gå inn på Superlab, velg Datafolder
    c. Marker det du ønsker å overføre og dra over til "e" (på høyre side av vinduet – under "min datamaskin")
    d. Følg så instruks for trygg fjerning av flyttbar enhet.

Prosedyre for HRV-tester

(Sist oppdatert: 12.jan 2015. jasl)

Info til deltakerne:

Hvorfor bruk av monitor?

- Hjerteratevariabilitet
- Akselerasjon

Når skal monitor brukes?

- onsdag kveld til torsdag morgen (ca kl. 09 torsdag skifte monitor)
- torsdag morgen til fredag morgen (fredag morgen levere monitor i resepsjon)
- torsdag kveld får deltaker med seg monitor til å sette på søndag
- søndag morgen til mandag morgen(deltaker får sms-påminning søndag morgen om å sette på ny monitor). Fjernes mandag morgen. Leveres Vea (adm) innen torsdag)
- Hvis monitoren ikke virker søndag: ekstra monitorer ligger i hylla over skap (adm.rom)

Hvordan skal den brukes?

- Husk å slå på monitoren etter montering (rød knapp trykkes ca 5 sek, til grønt lys blinker)
- Kneppes av ved dusjing (trenger ikke slå den av)
- Sjekk at den er på (blinker) når den settes på etter dusjing, evt skru den på igjen
- Fra deltaker våkner til hun står opp: prøve å ligge og hvile 5-10 minutter

Lagring av HRV-målinger:

Når monitoren er tilkoplet maskinen, og innholdet er lastet ned (download), brukes "Save-ikonet" til å lagre innholdet. Data lagres på følgende fil:

Dokumenter/Mine dokumenter/Arbeidstid/HRV_data PC2

Data lagres som hhv

KIDnr_HRV1, **KIDnr_HRV2** og **KIDnr_HRV3** for 1., 2. og 3. måling (eks K002_HRV3)

Alle målinger skal i tillegg til å lagres på PC 2, også lagres på minnepinne, som oppbevares på et trygt sted. Videre overføres data fra minnepinne til JASL sin PC på STAMI.

Prosedyre for gjennomgang av oppmerksomhetstester (3-test, Diamond-test)
Oppdatert: 6. januar 2015

For alle tre testene gjelder det at ved første gang (basismålingen), skal testene 1) demonstreres, og 2) øves på, før den virkelige testen kjøres. Programmene for demo og øvelse er lagt i samme fil, mens programmet for den egentlige testen er i en annen fil.

Testene er lagret under ikonet ”Superlab” på skrivebordet. Når an dobbeltklikker på dette, kommer man inn i mappen ”Superlab”, der ikonet til begge fulltestene ligger:

STAMI_Diamond_Test_Full test (ACT-testen)
STAMI_Digit_3_Full test (SART-testen)

I tillegg finner man her 3 mapper, den ene heter ØVELSE, og i den finner man:

STAMI_Diamond_Test_DemoPractice
STAMI_Digit_3_ DemoPractice

<u>Deltakerne starter med 3-testen. Først Demo og øvelse:</u>
Superlab/ØVELSE/ STAMI_Digit_3_ DemoPractice
Klikker man på denne, kommer det opp en melding:

”This experiment file is older than this version of SuperLab” **Klikk OK**

Man har nå oppe menyen for “SuperLab 5.0”

Lengst til høyre blant ikonene i raden øverst, er det en pil for RUN. **Klikk denne**

Opp kommer menyen ”Run Experiment”

Session_ID: trenger ikke fylle inn noe her
Participant name: Fyll inn: KIDnr_SAR1_ov
(*IDnr* unikt, *SAR1* for SAR-test og 1. gang; *ov* for Demo/øvelses-kjøringen)
Save collected data. Denne må være krysset av!
RUN

Kommer opp ny meny: ”Save the collected data file as”

“Filnavn”: Fyll inn samme deltakernavn som i forrige meny: KIDnr_SAR1_ov
Lagre

Deretter blir skjermen svart med flg tekst:

”The Digit-3 test” KLAR? **Klikk Q**, og testen kjører.
Dette er DEMO-kjøring, der vi kan forklare mens testen går.

Når den er ferdig kommer flg tekst:

”*Er du klar for en prøverunde? Trykk mellomrom for å starte*.” Klikk **SPACE**

Når prøverunden er ferdig, kommer teksten:

”*Si fra til forsøksleder at du er ferdig med øvelsen*”

Klikker man SPACE-tasten kastes man tilbake til menyene.

Så virkelige 3-test:

Forsøksleder må deretter gå tilbake til mappe og merke programmet:

Superlab /STAMI_Digit_3_Full test. **Klikk return**

Også nå kommer flg melding opp:

"This experiment file is older than this version of SuperLab" **Klikk OK**

Opp kommer menyen "Run Experiment"

Session_ID: trenger ikke fylle inn noe her

Participant name: Fyll inn: KIDnr_SAR1 (dette er den virkelige testen)

Save collected data. Denne må være krysset av!

RUN

Kommer opp ny meny: "Save the collected data file as"

"Filnavn": Fyll inn samme navn på deltaker som i forrige meny: KIDnr_SAR1

Lagre

Deretter blir skjermen svart med flg tekst "The Digit-3 test" ER DU KLAR?

Klikk SPACE, og testen kjører.

Etter at testen er ferdig kommer flg tekst:

"*Si fra til forsøksleder at testen er ferdig*"

Forsøksleder lukker programmet, før maskinen forlates.

ACT-testen (diamanttesten)

Obs: I denne testen må vi fordele deltakerne på vertikal høyre og vertikal venstre

Superlab/ØVELSE/ STAMI_Digit_3_ DemoPractice
Klikker man på denne kommer to meldinger opp:

”This experiment file is older than this version of SuperLab” **Klikk OK**
“Possible behavior change. Please retest the feedbacks used by..” **Klikk OK**

Man har nå oppe menyen for “SuperLab 5.0”

Lengst til høyre blant ikonene i raden øverst, er det en pil for RUN. **Klikk denne**

Opp kommer menyen ”Run Experiment”

Session_ID: Trenger ikke fylle inn noe her
Participant name: Fyll inn: KIDnr_ACT1_test
(*IDnr* unikt, *ACT1* for ACT-test og 1. gang; *test* for Demo/test-kjøringen)
Participant Group: Fyll inn vekselvis “Vertical Right Group” og “Vertical Left Group”
Save collected data. Denne må være krysset av! **RUN**

Kommer opp ny meny: ”Save the collected data file as”

“Filnavn”: Fyll inn samme deltakernavn som i forrige meny: KIDnr_SAR1_test
Lagre

Deretter blir skjermen svart med flg tekst

”The Diamond test DEMO” (her forklarer vi mens testen går)

Når den er ferdig kommer flg tekst:

”*Er du klar for en prøverunde*?” Klikk ”Q” for å starte prøverunden.

Når prøverunden er ferdig, får vi teksten

”*Dette var øvelsen. Er du klar for selve testen?*” Må klikke på ”Q” for å komme ut.

Starting av selve testen

Superlab/STAMI_Diamond_Test_Full test.
Klikke OK på de to pop-up vinduer, som beskrevet ovenfor
Oppgi deltakers navn (identisk i to påfølgende menyer), som beskrevet ovenfor.

Når testen settes i gang, kommer først en 2 min øvelse (viktig ved 2. og 3. gangs måling)
Det første som vises er tesksten:

”*The Diamond test*
Høyre for loddrett, Venstre for vannrett (avhengig av hvilken som er valgt)
Er du klar for en 2 min øvelse av testen?” Klikk SPACE (el Q?) for å starte.

Når 2-minutters øvelsen er ferdig, kommer teksten:

”*The Diamond test*

Høyre for loddrett, Venstre for vannrett (avhengig av hvilken som er valgt)
Er du klar for testen?"
Etter avslutning av testen kommer teksten

> "*Takk for innsatsen!*
> *Si fra til forsøksleder at du er ferdig*"