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RESEARCH REPORT

Literature review regarding Considerations concerning the effects of shift work and fatigue of HEMS pilots aged 60-65

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SUMMARY

Helicopter Emergency Medical Services (HEMS) are on-demand operations with very short action notice, (long) breaks at the HEMS base, multiple short missions, mostly visual flight rules operations (VFR) often in unpredictable operational conditions to unknown landing sites. Flight times and rest periods in HEMS are today regulated in Europe at Member States' level. This leads in some States to long duty hours — e.g., daily FDPs with extension of over 15–16 hours, as well as to reduced rest times from 6 to 11 hours. There is considerable variability in cumulative duty and block hours, as well as in the way States regulate airport (base) and other standby.

In the context of extending the age limit for HEMS pilots from 60 to 65 years it is considered that age is a major risk factor for cardiovascular and cerebrovascular risk (CVD). Because age is the key determinant of CVD risk and CVD events are the major causes of medical pilot incapacitation in-flight, it is considered that an extended cardiovascular risk assessment is necessary for medical certification if the age limit for single pilot HEMS operations is extended from 60 to 65 years. Although considerable variation is found in the organisation, scheduling, and daily practice of HEMS operators, job circumstances in HEMS operations may lead to fatigue and sleep deficit. Because it is known that sleep deprivation, shift work, and fatigue has the potential to increase cardiovascular and cerebrovascular risk, it is important to reduce these additional risk factors as much as possible in order to further mitigate the CVD risk and the consequent risk of in-flight incapacitation. In that context, the effects of sleep deficit and fatigue on cardiovascular health are discussed in the present paper and recommendations are made to mitigate these additional risk factors.

Findings

There is convincing evidence that sleep deprivation is associated with markers of metabolic syndrome, increased risk of cardiovascular diseases, and coronary heart diseases. There is also convincing evidence that frequent exposure to long working hours (≥55 hours per week) or frequent overtime work (3-4 hours overtime per average weekday) is associated with higher risks of stroke, ischemic heart disease, and atrial fibrillation.

Recommendation

Based on the above-mentioned findings, it is recommended to use fatigue risk management principles tailored to each specific HEMS enterprise to reduce fatigue and sleep deprivation risks as much as possible in order to optimise the general and cardiological fitness of pilots.

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1. Introduction

Helicopter Emergency Medical Services (HEMS) are on-demand operations with very short action notice, (long) breaks at the HEMS base, multiple short missions, mostly visual flight rules operations (VFR) often in unpredictable operational conditions to unknown landing sites. Flight times and rest periods in HEMS are today regulated in Europe at Member States' level. This leads in some States to long duty hours — e.g., daily FDPs with extension of over 15–16 hours, as well as to reduced rest times from 6 to 11 hours. There is considerable variability in cumulative duty and block hours, as well as in the way States regulate airport (base) and other standby. In the context of extending the age limit for HEMS pilots from 60 to 65 years it should be considered what the possible effects of above-mentioned job conditions will be on health and performance of HEMS pilots belonging to this age category.

There is general consensus that individuals above the age of 60 have a higher risk of cardiovascular disease (CVD) and a higher mortality from CVD than younger individuals and, therefore, a higher risk of incapacitation due to cardiovascular events. This was confirmed by the age limit study conducted on behalf of EASA by a consortium led by TNO. In this study all cardiovascular and cerebrovascular diseases were classified as cardiovascular disease (CVD), which classification will also be used in the present report. The EASA study concluded that the incapacitation risk due to CVD of the 55-64 age group is just within the margin of the acceptability limit for catastrophic system failures for single piloted CS23 aircraft with a single reciprocating engine and a seating capacity for 0-6 passengers (EASA, 2019). Bauer et al. (2018) performed the only study that specifically assessed the CVD risk of HEMS pilots older than 60 years by assessing the medical examination reports with an average follow-up of 8.52 years of 66 German, Austrian, Polish, and Czech HEMS pilots of who 10 had passed the age of 60 at their last available medical examination. The authors found that the cardiometabolic risk marker profile of HEMS pilots appeared to improve over time in pilots nearing age 60, compared to younger pilots. Apart from a possible healthy worker effect, a major limitation of this study was its small sample size and the associated large estimation uncertainty, especially regarding the critical group of pilots aged 60 and over.

Despite the favourable outcome of this small study, all CVD risk estimation models show that age is a key determinant of CVD risk (EASA, 2019). When the age limit is extended from 60 to 65 years, it is, therefore, considered necessary to implement additional risk mitigating measures beyond the implementation of specific requirements of the medical certification, such as an extended cardiovascular risk assessment, pulmonary assessment, screening for obstructive sleep apnoea (OSA) syndrome, screening for cognitive decline, a comprehensive eye examination, and a comprehensive ear, nose and throat examination. In this context, it is considered that extra risks caused by specific operational conditions should be prevented as much as possible in order to further mitigate the cardiovascular and cerebrovascular risk and consequent risk of in-flight incapacitation.

Additional risk factors for CVD associated with HEMS operations

Although age is a key risk factor for CVD, it is known that sleep deprivation, accumulation of sleep deficit and fatigue has the potential to increase cardiovascular and cerebrovascular risk (Ningjian Wang et al., 2021; Daghlas et al., 2019; Mullington et al., 2009; Kohansieh & Makaryus, 2015; He et al., 2017; Ekmann et al., 2012). Although the organisation, scheduling, and daily practice of HEMS operators may vary considerably, these operations often involve shift work and/or on call duties. Therefore, job circumstances in HEMS operations may lead to fatigue and sleep deficit. Because HEMS crew members are considered to be potentially at risk for fatigue and sleep deficit and these factors are known to be risk-increasing factors for cardiovascular and cerebrovascular diseases (CVD), the aim of the present report is to discuss the effects of fatigue and sleep deficit on CVD risk.

Factors that determine the levels of fatigue of flight crew members are (Simons, 2017):
- Time on Task
- Time since awake
- Amount and quality of Pre-Duty Sleep
- Cumulative sleep debt
- Phase of Circadian Cycle
- Workload
- Cabin environmental conditions
- Medication, residual effects, hangover
- Health disorders
- Psychological factors and life stress

Operational causes of sleep deficit and fatigue in HEMS operations are shift work, long shifts, high workload, impaired sleep while on call or on-duty, and operational stress. During night shifts fatigue levels may be increased and alertness levels will be lowered due to the circadian system dictating sleep at night. Night time fatigue and sleepiness on the job will be potentiated by the consequences of poor recovery sleep during the day caused by the circadian clock dictating activity at daytime.

Fatigue occupies a special place in the range of mental problems as it adversely affects pilot's functioning and health. The European Union Aviation Safety Authority (EASA) and the International Civil Aviation Organisation (ICAO) FRMS subgroup, describe fatigue as: "A physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness and/or physical activity that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety related duties." Severe acute or chronic fatigue or sleep deprivation can affect cognitive functioning and result in subtle incapacitation. Subtle incapacitation is a potential threat to flight safety because it may lead to a chain of errors with potentially fatal consequences.

There are major differences between individuals in terms of tolerance to stressors such as fatigue, disruption of the circadian rhythm, lack of sleep, or stressful missions (Van Dongen, 2006). Resilience to these stressors is also related to the motivation of pilots to do their flying job. If the motivation is no longer there the accumulation of mental fatigue due to shift work and other operational stressors may be more damaging that in the case of pilots that are fully motivated and committed to fly. Consequently, in the best interest of flight safety it is recommendable that pilots who are no longer motivated to continue flying until they reach the age of 65 years, due to health or psychological reasons, should have reasonable opportunities (economically, legally) to stop working.

The most important adverse effects of sleep deprivation and fatigue on performance of flying tasks are:
- impaired judgment and decision making
- impaired communication skills
- narrowing of attention, lapses in attention, and impaired ability to recall information
- slower reaction times
- risk-taking behaviour
- irritability

In an operational context of adverse flight conditions, these symptoms may cause aircrew to:
- choose wrong priorities; focus on only one task
- be unaware of a dangerous situation
- ignore alarm signals and neglect normal checks and procedures
- choose risky options
- be unaware of impaired task performance

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Sleep deficit and fatigue are also related to increases in health issues and difficulty dealing with home and social life. Health issues include, but are not limited to:

- Heart disease and high blood pressure
- Depression, anxiety, and stress
- Gastrointestinal disorders
- Increased alcohol and drug use
- Lower sense of overall well-being

The above cognitive, operational, and health effects emphasize the importance of fatigue risk management in order to optimize pilot's sleep and reduce fatigue risk as much as possible.

2. Sleep

2.1 Do 60-65 years old active pilots have more sleep problems than younger age groups?

It is commonly believed that older people have a shorter and more fragmented or disturbed sleep than younger people. Aging is associated with decreased ability to maintain sleep (increased number of awakenings and prolonged nocturnal awakenings), reduced nocturnal sleep duration, and decreased deep sleep (slow wave sleep) (Foley et al., 2004). Although data of other authors generally confirm this observation, it is questionable if this also holds for active HEMS pilots aged 60-65 because almost all scientific data of sleep in the elderly have been collected in studies of much older (>65+) retired people. These 'grey panthers' often have a different sleep-wake pattern than working people and their data cannot be 1:1 transferred to active HEMS pilots aged 60-65. Although there have been a few studies assessing sleep in HEMS crews, sleep problems have not been assessed in detail in older HEMS crew. In long-haul pilots it was found that sleep quality and duration did not significantly differ between younger and older pilots (Valk et al., 2003; Reis et al., 2016). However, these results may be partly explained by a healthy worker effect.

2.2 Sleep during on-call duty and on-duty sleep

On-call or stand-by is a form of scheduling whereby an employee can be called into work under emergency or unpredictable circumstances. The industries that typically utilise on-call working arrangements include health care, emergency services, and maintenance. On-call arrangements are often utilised when workloads may be low; as such they typically occur outside of normal working hours, particularly at night. There is evidence suggesting that being on-call, regardless of whether an employee is actually called, can also adversely impact sleep duration. In an online questionnaire survey completed by 228 Australian on-call workers, Vincent et al. (2021) found that 80% of the workers slept less than 7 hours per night when on-call, and 56% of them reported that sleep was impacted on-call even when no-calls were received.

Torsvall and Akerstedt (1988) investigated the effects on-call duty on sleep and wakefulness in five male ships' engineers using electroencephalogram (EEG) and electrocardiogram (ECG) recordings and subjective ratings. Sleep during on-call nights (two alarms) was shortened and contained less slow wave sleep (SWS) and rapid eye movement (REM) sleep, lower spectral power density, and a higher heart rate. Many of the effects were observable before any alarms had occurred. Subjective ratings of sleep quality were lower, and sleepiness ratings were higher during the subsequent day. The authors suggested that the effects might have been caused by apprehension/uneasiness induced by the prospect of being awakened by an alarm.

To be recuperative the duration of sleep should be sufficiently long to allow for deep sleep (slow wave sleep) and rapid eye movement (REM)-sleep. Sleep duration is the principal determinant of the recuperative value of sleep (Dinges et al., 1997; Wilkinson et al., 1966). Duty planners should therefore consider that sleep during on-call duty and on-duty sleep is in most cases less recuperative than 7–8-hour sleep during a free night at home. Frequent on-call or on-duty sleep may lead to sleep debt that might become a CVD risk factor.

2.3 Sleep duration and cardiovascular risk

Self-reported short sleep duration (<6 hour/night) as well as long sleep (>9h/night) has been associated with markers of metabolic syndrome and increased risk for morbidity and mortality in several studies (e.g., Arora et al., 2011; Cappuccio et al., 2011; Itani et al., 2017; Jike et al., 2018), but associations might be obscured by illness or undiagnosed sleep or mood disorders. E.g., symptoms of illness might force individuals to get out of

bed earlier than desired or keep patients longer in bed. Hall et al. (2009) found that the odds for having the metabolic syndrome increased by more than 45% in both short and long sleepers, compared with those sleeping 7 to 8 hours per night. Sleep duration was also associated with obesity, elevated fasting glucose, and hypertriglyceridemia.
Sleep duration of more than 9 hours is not likely to play a role on duty days of HEMS pilots. In the context of HEMS operations, it is, therefore, more relevant to consider the effects of sleep deprivation.

Mullington et al. (2009) found that with short term sleep deprivation blood pressure, inflammation, autonomic tone, and hormones are altered in a direction that is recognized to contribute to the development of atherosclerosis and cardiovascular disease. Although the magnitude of change was similar to that seen in profiles predicting future CVD risk, the changes seen in the experimental models of total and partial sleep deprivation were mild and resolved quickly with recovery sleep.

In a meta-analysis of 153 studies comprising 5,172,710 participants Itani et al. (2017) found that short sleep (<6 hours) was significantly associated with the mortality outcome (RR 1.12; 95% CI, 1.08–1.16), diabetes mellitus (RR 1.37; CI 1.22–1.53), hypertension (RR 1.17; CI 1.09–1.26), cardiovascular diseases (RR 1.16; CI 1.10–1.23), coronary heart diseases (RR 1.26; CI 1.15–1.38), and obesity (RR 1.38; CI 1.25–1.53).

Daghlas et al. (2019) investigated associations between self-reported sleep duration and documented incident myocardial infarction, accounting for joint effects with other sleep traits and genetic risk of coronary artery disease and assessing causality using Mendelian randomization (MR). This was assessed in 461,347 UK Biobank (UKB) participants free of relevant cardiovascular disease who were followed-up for a median of 7.04 years. The authors concluded that prospective observational and MR analyses support short sleep duration (<6 hours) as a potentially causal risk factor for myocardial infarction (HR: 1.21; 95% CI:1.08 to 1.37).

It can be concluded that studies show that insufficient sleep alters established cardiovascular risk factors in a direction that is known to increase the risk of cardiac morbidity.

2.4 Shift work: effects on sleep and cardiovascular/cerebrovascular (CVD) risk

Shift work is loosely defined as any shift that falls outside the hours of 6 am and 7 pm, including fixed and rotating hours (Bureau of Labor Statistics, 2019). Scientific data of shift workers indicate an increased risk for cardiovascular and cerebrovascular diseases, disturbed sleep, and fatigue in shift workers (Ningjian Wang et al., 2021; Torquati et al., 2018; Richter et al., 2016; Akerstedt & Wright, 2009). Moreover, it was found that tolerance to shift work and circadian disturbances declines in older shift workers (Blok & de Looze, 2011). There is evidence that shift workers have more sleep problems than non-shift workers (Boivin & Boudreau, 2014; Casjens et al., 2022). This was also found in long-haul pilots flying night or early morning flights, or experiencing jet lag (Valk et al., 2003; Reis et al., 2016).

It is questioned, however, whether this is true for HEMS pilots because their schedules and circadian conditions differ completely from industrial or hospital shift workers or airline pilots. Results of studies of pilots aged 60-65 are difficult to interpret because of the ‘healthy worker’ effect, causing pilots who cannot cope with the demanding schedules to retire or change to another job. All studies of the tolerance to shift work and circadian disturbances of older pilots may be hampered by the healthy worker effect: those who can cope with the job circumstances will be more tolerant than those who have left the job because they could not cope.

The few sleep studies in HEMS crew show variable results, which may be explained by variations in rosters, and operational demands and environments. There are operational differences between search and rescue, firefighting, emergency medical services, and offshore transfer services. There are also differences between HEMS operators in the frequencies of night time or daytime duties and in the rest facilities they have for pilots to sleep at the airbase between duties or during standby or on-call duties. Some studies only concerned the medical staff members of HEMS operation (Frakes & Kelly, 2007). Results of these studies are not representative for pilots because most medical staff members had a hospital job in addition to their HEMS work and therefore had different workloads and rostering than HEMS pilots.

In a study of 24 Dutch HEMS pilots, Radstaak et al. (2014) found that distressing shifts were related to delayed sleep onset ($r = 0.50$, $p = 0.026$) and higher workload was correlated with impaired subjective sleep quality ($r = -0.42$, $p = 0.044$). Although these linear correlations are statistically significant, they are very small. Calculating the coefficient of determination (r^2) shows that they respectively predict only 25% and 18% of the variance.

Fletcher et al.(2022) studied 210 pilots (77% - 64 % rotary wing and 13% fixed wing), other crew (9%), and technicians (14%) employed by companies that provided rotary and fixed wing emergency medical services (EMS -70%), search and rescue (SAR - 9%), firefighting (14%), and air transfers (7%). Companies were operating from 90 bases in France, Italy, Spain/Portugal, Sweden, Finland, and the United Kingdom. Participants kept sleep diaries including sleep quality ratings and wore altigraphs to allow for collection of objective sleep variables. For the EMS and SAR operations the average duty period length was 7.0 hours (SD ± 2.7 h). Most work occurred during the daytime, and most sleep during night-time hours. The amount of sleep that occurred during duty time ranged from none in EMS in the UK, up to nearly 30% in Spain SAR. Mean length of a sleep period on duty was 3.4 hour (SD ± 1.8 h), which was significantly shorter compared to off duty sleep length (mean = 6.5 h, SD ± 0.3 h). Total 24 h sleep time across all participants was significantly shorter on duty days (5.9 h, SE ± 0.1 h) compared to non-duty days (6.9 h, SE ± 0.1 h).
On average, duties starting during the day between 10.00 and 16.59 h were associated with higher amounts of prior sleep than duties starting between 06.00 and 07.59 h. Average 24 h and 48 h sleep times were significantly longer prior to the first, compared to subsequent shifts in a sequence.
Overall, mean response times on the Psychomotor Vigilance Task (PVT) were significantly longer on duty days compared to non-duty days with a mean difference of 2 milliseconds. Although this difference is statistically significant its magnitude is considered to have no practical relevance. Lapses, as measures of lowered alertness, were not measured or reported by the authors.
Overall results of this large ambitious study indicate that the total sleep time (TST) per 24 hours was 1 hour shorter on duty days than on non-duty days. The mean TST of 5.9 hours which was found on duty days falls in the range of concern (TST <7 h) as defined by the American Academy of Sleep Medicine (AASM) and Sleep Research Society. The AASM recommendations mention that sleeping less than 7 hours per night on a regular basis is associated with adverse health outcomes, including weight gain and obesity, diabetes, hypertension, heart disease and stroke, depression, and increased risk of death. Sleeping less than 7 hours per night is also associated with impaired immune function, impaired performance, increased errors, and greater risk of accidents (Ramar et al., 2021; Watson et al., 2015).

The study of Fletcher et al. (2022) shows that there are significant differences in the nature, organisation, and work circumstances of the emergency operations of the various companies in the different European countries. Therefore, it should be considered that the results are not generalizable to apply for each EMS company and measures to reduce fatigue risks should be tailored to the specific operational circumstances and organisation of the HEMS company concerned.

Excessive sleepiness during free days has been found in studies among shift workers (Härmä et al. 2018), suggesting that accumulated sleep deprivation during the work period may become manifest on days off work.

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In HEMS pilots, increased sleepiness was found during the 2 weeks off, although not of pathological levels, compared with the week when they were working. (Flaa et al., 2019). A Fatigue Risk Management System (FRMS) was found to be effective in mitigating the potential negative impact at operational level.

The increased risk of CVD in shift workers is attributed to an unfavourable effect of shift work on CVD risk factors, such as a high Body Mass Index (BMI), and an unhealthy lifestyle and diet (Vyas et al., 2012). However, this has insufficiently been studied in HEMS crew. The work shifts in HEMS and other emergency services are not comparable to the shifts of the non-aviation shift workers that were studied thus far. HEMS crews fly fewer hours than their airlines equivalents and non-scheduled operations require more flexibility because last minute changes occur at short notice making planning difficult. Flaa et al.(2019) found that in HEMS flight crew having higher workload was associated with lower sleepiness scores compared to having medium workload. In contrast, having higher total working times was associated with higher sleepiness scores compared to medium total working times. These results may indicate that the activation related to more missions reduced sleepiness levels, while the activation related to longer missions did not.

The effects of the HEMS work environment on longer term CVD risk have not been studied. A study by Strauss et al. (2021) showed that HEMS pilots experience a significant load on the cardiovascular system during rescue operations causing increase of blood pressure, heart rate, and occasional supraventricular extrasystoles (PACs) and ventricular extrasystoles (PVCs) during the mission. However, this is likely to be caused by a normal stress reaction which may not directly be interpreted as a considerable CVD risk. Similar observations are reported in airline pilots during take-off and landing and occurrence during these stressful phases of flight of some PACs or PVCs is considered to be clinically insignificant as long as pilots have no electrophysiological abnormalities such as a long-QT, WPW, or Brugada syndrome.
A recent study of Vaccarino et al. (2021) provides compelling evidence demonstrating a strong association between mental stress ischemia and the risk of future cardiac events and mortality among individuals with stable Coronary Heart Disease. Therefore, we agree with Strauss et al. (2021) that it is necessary to carry out a stratified risk assessment of the HEMS crew members to prevent cardiovascular risk and events.

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3. Long working hours (time on task) and CVD risk

The effects of fatigue on health of HEMS crew have not been systematically studied up to now. For workers in non-aviation jobs, there is evidence that frequent exposure to long working hours (≥55 hours per week) or frequent overtime work (3-4 hours overtime per average weekday) is associated with increased risks of fatal and non-fatal coronary heart disease (CHD), stroke, and atrial fibrillation (Virtanen et al., 2010; Kivimäki et al., 2015; Kivimäki et al., 2017; Hayashi et al., 2019). In a systematic meta-analysis on CHD of 25 studies from 24 cohorts in Europe, USA, and Australia, Kivimäki et al. (2015) analysed data of 603,838 men and women who were free from CHD at baseline and were followed for an average of 8.5 years. The authors also followed 528,908 men and women who were free from stroke at baseline for 7.2 years. Working ≥55 hours per week was associated with an increased risk of incident CHD (relative risk [RR] 1·13, 95% CI 1·02-1·26) and incident stroke (RR 1·33, 95% CI 1·11-1·61). The authors found a dose-response association for stroke, with RR estimates of 1·10 for 41-48 working hours, 1·27 for 49-54 working hours, and 1·33 for 55 working hours or more per week compared with standard working hours. In addition to these findings, the IPD Work Consortium (Individual-Participant Data meta-analysis in working populations; Kivimäki et al., 2017) found that individuals who worked ≥55 hours were more likely to develop atrial fibrillation than those working standard hours (Hazard Ratio 1.42, 95% CI 1.13-1.80).

Evidence for the association between long working hours and myocardial infarction was also found in the Japan Public Health Center-Based Prospective Study Cohort (Hayashi et al., 2019). This study involved 15,277 men aged 40–59 years at the baseline survey in 1993 who were followed up until 2012. Cox proportional hazards models adjusted for sociodemographic factors, cardiovascular risk factors, and occupation showed that multivariable-adjusted hazard ratios (HRs) associated with working more than 11 hours per day were 1.63 (95% confidence interval [CI] 1.01–2.63) for acute myocardial infarction and 0.83 (95% CI 0.60–1.13) for total stroke, as compared with the reference group who worked between7 and 9 hours/day. Increased risk of acute myocardial infarction associated with working hours of ≥11 h/day was more evident among salaried employees (HR 2.11, 95% CI 1.03–4.35) and men aged 50–59 years (HR 2.60, 95% CI 1.42–4.77). This long-term cohort study involving middle-aged men, with a median follow up of 20 years, found that working ≥11 h/day was significantly associated with increased risk of acute myocardial infarction. It is noteworthy that in contrast to the findings of the above-mentioned studies, no association with stroke was found. This might be explained by the much lower proportion of thromboembolic infarction in Japanese than Caucasian in populations (Hayashi et al., 2019). For a Caucasian population a positive association of work time with progression of carotid atherosclerosis in middle-aged men has been shown in a prospective study of 621 middle-aged Finnish men in which baseline and repeat measures of work time showed progression of ultrasonographically assessed carotid intima-media thickness (IMT) and interactions with cardiovascular disease (Krause et al., 2009). These effects on atherosclerosis were most outspoken in those with pre-existing cardiovascular disease.

The above findings are in agreement with a recent global analysis of the loss of life and health associated with working long hours, in which WHO and ILO found that working 55 or more hours per week is associated with an estimated 35% higher risk of a stroke and a 17% higher risk of dying from ischemic heart disease, compared to working 35-40 hours a week (Pega et al., 2021). This work-related disease burden was particularly significant in men, people living in the Western Pacific and South-East Asia regions, and middle-aged or older workers. Most of the deaths recorded were among people dying aged 60-79 years, who had worked for 55 hours or more per week between the ages of 45 and 74 years (Pega et al., 2021).

Concerning regular overtime work, Virtanen et al. (2010) studied a population of 6014 British civil servants aged 39-61 years (4262 men and 1752 women), who were free from CHD and worked full time at baseline. After an

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average follow-up of 11 years, it was found that 3-4 hours overtime work per average weekday was associated with 1.67-fold (95% CI 1.02-2.76) increased risk of fatal cardiovascular disease and incident non-fatal myocardial infarction.

In a retrospective study, including all baseline participants (n=137 854) from the French population-based cohort CONSTANCES, Fadel et al. (2020) found that exposure to long working hours (>10 hours on ≥50 days/year) was associated with an increased risk of IHD with an adjusted odds ratio (aOR) of 1.24 (1.08–1.43). In stratified analyses, this effect was not observed in women, but was significant among men: aOR 1.28 (1.11–1.48).

Also using the French CONSTANCES cohort, Virtanen et al. (2019) performed a cross-sectional study of a random population-based sample of 75 709 participants aged 18–69 at study inception in 2012–2016. The data included survey responses on working hours (never, former or current exposure to long working hours), covariates and standardised biomedical examinations including anthropometry, lung function, blood pressure, and standard blood-based biomarkers. Virtanen et al. (2019) found that long working hours (>10 hours on ≥50 days/year) was associated with higher body mass index (BMI), waist circumference and waist/hip ratio, adverse lipid levels, higher glucose, creatinine, white blood cells and higher alanine transaminase (ALAT). A dose-response pattern with increasing years of working long hours was found for total cholesterol, glucose, and γ-GT. It was concluded that men who work long hours might become a risk group with an adverse cardiometabolic risk profile. For women the associations were weaker except for BMI.

Because the effects of long working hours and overtime work of pilots may result in an increase of cardiovascular risk factors, the incapacitation risk concerning long working hours is likely to be heralded by a higher CVD risk score using a risk calculator. These workers might therefore be identified during a stratified CVD risk assessment as a part of the medical screening.

Unfortunately, fatigue levels were not measured in the above-mentioned studies and therefore these studies provide no hard evidence for a direct relation between fatigue levels and CVD risk. One of the scarce studies on a direct relation was done by Ekmann et al., 2012, who studied 5216 middle-aged Danish men born in 1953 who were at baseline free of angina pectoris and previous ischemic heart disease (IHD) and were asked if they felt fatigued. After 4-years follow-up, information on IHD diagnosis and all-cause mortality was collected form the health register. Using a Cox proportional hazard model and taking smoking status into account, the authors concluded that fatigue is a potential risk indicator for IHD and mortality. The evidence for this conclusion is, however, quite weak because the study participants were only asked whether or not they felt “fatigued”. Apart from this unspecific subjective outcome variable, it should also be considered that fatigue is a common symptom of IHD. Therefore, a causal relationship between fatigue and IHD risk is difficult to substantiate. In studies among CVD patients, it is found that higher fatigue levels are correlated with worse cardiac outcomes. Here, the ‘chicken and egg’ question might be at play because it is known that fatigue can be a symptom of heart disease.

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4. Conclusions

Because age is the key determinant of CVD risk and CVD events are the major causes of medical pilot incapacitation, it is considered that an extended cardiovascular risk assessment is necessary for medical certification if the age limit for single pilot HEMS operations is extended from 60 to 65 years. To further reduce the CVD risk, it is considered necessary to include additional risk mitigating measures in concert with an extended cardiovascular risk assessment. In this context, it is considered that extra CVD risks that may be related to operational HEMS conditions should be prevented as much as possible. Although considerable variation is found in the organisation, scheduling, and daily practice of HEMS operators, job circumstances in HEMS operations may lead to fatigue and sleep deficit. Because it is known that sleep deprivation, shift work, and fatigue has the potential to increase cardiovascular and cerebrovascular risk, it is important to reduce these additional risk factors as much as possible in order to further mitigate the CVD risk and the consequent risk of in-flight incapacitation and adverse health.

Results of studies of general working populations provide convincing evidence that sleep deprivation is associated with markers of metabolic syndrome and increased risk of cardiovascular diseases, and coronary heart diseases. There is also convincing evidence that frequently working long hours (≥55 hours per week) and overtime work (3-4 hours per average weekday) are associated with a higher risk of stroke and a higher risk of ischemic heart disease.

Recommendations

In the context of the association of long work hours, sleep deficit, and shift work with an increased CVD risk, it is recommended to take company-tailored measures to reduce fatigue risks. Although such measures might be considered to apply for pilots from the age of 60 onwards, it might be useful to reduce fatigue as a CVD risk factor also for younger age categories. Due to lack of dedicated studies, it is not clear how the cumulative CVD risk will be affected after numerous years of exposure to long and irregular working hours before their 60th birthday. However, by limiting the working hours and providing sufficient opportunities for sleep the risk for CVD and cerebrovascular disease due to fatigue may not be further increased and, with time passing, this risk may be expected to gradually reduce. It is concluded that measures to reduce fatigue and sleep deficit could lead to an increase in the general and cardiological fitness of older pilots.

With regards to the above-mentioned considerations, it should be emphasized that sufficient (around 7 hours) sleep of good quality is a key factor in preventing fatigue and maintaining optimal performance and good health (e.g. ICAO, 2011; Simons, 2017). It is therefore recommended that an operator should strive to provide its flight crew members an 8-hour sleep opportunity per 24 hours. Sleep should be facilitated in a dark and quiet environment allowing horizontal rest (ICAO, 2011).

Fatigue Risk Management (FRM) may be efficiently used to reduce the accumulation of fatigue and the inherent risks. Consequently, it is recommended that HEMS operators implement FRM practices tailored to the specific operational circumstances and organisation of their company. Pilots and managers should be educated to stimulate awareness of the safety implications of fatigue, recognise the signs of fatigue, and learn how to prevent fatigue by sufficient sleep and strategic naps.

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