REVIEW

THE ELEVATED RISK OF MELANOMA AMONG PILOTS – COULD UVA BE IMPLICATED?

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ABSTRACT

A number of studies indicate that pilots have approximately double the risk of developing melanoma compared to the general population. It is not clear which aetiological factors underpin this increase in risk. Possibilities include leisure time sun exposure, cosmic radiation, circadian rhythm disruption and UV exposures in the cockpit. This brief review presents some of the key research on exposures of interest, with a focus on UV radiation. It highlights the need for further research assessing UVA levels within the cockpit of flying aircraft, given the possibility that glass windscreens may not be particularly effective at blocking UVA.

INTRODUCTION

Globally, rates of melanoma in fair skinned populations have been increasing for several decades with New Zealand and Australia having the highest rates in the world. Although melanoma represents less than 10% of all skin cancers, it has a high metastatic potential and accounts for the vast majority of skin-cancer related deaths. Compared to the general population, airline pilots and cabin crew have approximately twice the risk of developing melanoma, with pilots also having double the mortality rate from melanoma compared to the population at large.(1) The aetiological basis for this increased incidence and mortality is unclear, with research to date focusing on UV radiation (both occupational and leisure time exposures), cosmic radiation and circadian dysregulation. This review presents some of the key research relating to melanoma risk in pilots, with a focus on UV radiation.

PILOTS AND CABIN CREW HAVE AN INCREASED INCIDENCE OF MELANOMA

Miura and colleagues recently published a systematic review reporting a standardised incidence ratio (SIR) for melanoma in pilots of 2.03 [95% confidence interval (CI) 1.71-2.40] and 2.12 in cabin crew [95% CI 1.71-2.62]. For pilots, the standardised mortality ratio (SMR) for melanoma was 1.99 [95% CI 1.17-3.40] and for cabin crew was 1.18 [95% CI 0.73-1.89]. Many previously published studies and systematic reviews have also shown that both pilots and cabin crew have higher than population rates of melanoma, although it is acknowledged that the data from which these conclusions were drawn were often decades old.(1-11)

A recent study of melanoma incidence in Australian certified commercial pilots found that pilots had a modestly raised risk of in-situ melanoma (SIR 1.39 [95% CI 1.08-1.78]) but no elevation in invasive melanoma compared with the general Australian population.(12) Given the high background rates of melanoma in Australia however, it is possible that this finding reflects a lower contribution of occupational exposure to total UV exposure in Australian certified commercial pilots. In the northern hemisphere, both ambient UV levels and melanoma incident rates are lower compared to Australia.

EXPOSURES OF INTEREST - COSMIC RADIATION, CIRCADIAN DYSRHYTHMIA AND UV EXPOSURE

The aetiological basis for the increased risk of melanoma in aircrew remains unclear. Possible contributing factors include occupational ultraviolet (UV) light exposure, leisure-time UV light exposure, cosmic radiation, and effects of circadian rhythm disruption due to shift work and time-zone changes. Untangling the cause or causes of the increased melanoma risk is challenging due in part to complex exposures (which are often simultaneous, making controlling for confounding very difficult), some small individual study sizes, and the fact that aircrew are a highly selected group.(13-15)

Cosmic ionising radiation is a known occupational exposure for aircrew and has been an area of research over the last 30-40 years, with concerns about a possible link to diseases such as melanoma, prostate and brain cancer. The International Agency for Research on Cancer (IARC) classifies neutrons, a component of cosmic radiation at flight altitudes, to be a known human carcinogen.(16) Pilots and cabin crew are considered radiation workers by the International Commission on Radiological Protection (ICRP) because of their occupational exposure to cosmic radiation. However, the estimated levels of ionising radiation that aircrew are exposed to is considered low, with a typical dose of 2-6mSv per year (compared to the occupational exposure limit for non-pregnant adults of 20mSv per year).[17] To date, no clear association has been demonstrated in epidemiological studies between cosmic radiation exposure and melanoma or other cancers in flight or cabin crew.[11,18,19]

Circadian dysrhythmia caused by shift work and time-zone changes is another common occupational exposure for pilots and cabin crew. IARC classify shiftwork that involves circadian disruption (in particular night work) as a probable cause of cancer based on animal and human studies.[20,21] It is thought that disruption of the circadian system may alter various homeostatic processes resulting in dysregulation of genes involved in tumour development. Gutierrez and colleagues reviewed skin cancer risk in association with circadian dysrhythmia and reported that the data is often contradictory, making it difficult to ascertain if a link between circadian dysrhythmia and skin oncogenesis exists or not.[22]

Ultraviolet radiation (UVR) is part of the electromagnetic spectrum that reaches the Earth from the sun and is known to cause skin cancers such as melanoma, basal cell and squamous cell carcinomas, as well as ocular damage such as cataracts and pterygium. UVA has the longest wavelengths (315-400nm) compared to UVB (280-315nm) and UVC (100-280nm). The earth's atmosphere blocks around 75% of the sun's UVR, almost entirely in the shorter UV wavelengths. The UVC portion of sunlight (which has the highest energies) is absorbed by stratospheric oxygen, which subsequently undergoes reactions to form ozone. The resulting ozone molecules absorb the majority of sunlight UVB. Thus, of the solar UVR wavebands that reach the earth's surface, approximately 95% are UVA and 5% UVB. The precise ratio of UVB to UVA varies with the solar zenith angle, which is determined by latitude, season and time of day. While UVA wavelengths transmit less energy than UVB and are therefore less genotoxic, UVA is far more prevalent and can penetrate both cloud and glass. UVA is also able to penetrate the skin itself more deeply than UVB (to the dermal layer rather than just the epidermis) and can transmit through some light coloured clothing materials.[23,24]

Historically UVB had been considered the exposure of concern in relation to skin cancers. A growing body of evidence shows that UVA as well as UVB is implicated in melanomagenesis. UVA can generate reactive oxygen species, causing oxidative damage to both DNA and to the proteins that repair DNA damage.[23,25-27] A strong association has been shown between use of sunbeds (which emit high levels of UVA compared to sunlight) and development of melanoma.[28,29]

While aircraft windscreens block UVB radiation effectively, multi-laminate glass windscreens commonly used in commercial jet airliners may allow some (variable) transmission of UVA radiation.[30] At 10,000m, a typical cruise altitude for a large commercial jet, the absolute levels of UVA outside the cockpit will be higher than at sea-level, and potentially increased further by reflection off clouds or a snow layer.[31]

UV RADIATION, PILOTS AND MELANOMA - THE OCCUPATIONAL VS LEISURE-TIME EXPOSURE DEBATE

Exposure to UV light is a known risk factor for development of skin cancers and is a possible cause or contributory factor for the observed increase in melanoma incidence among pilots. Some investigators have attributed this increased risk to non-occupational lifestyle factors, such as layovers or vacations in sunny regions.[10,32] Dos Santos Silva and colleagues, in comparing air traffic controllers and commercial pilots in terms of cancer incidence, concluded that the difference in melanoma rates between pilots and the general population was due to leisure time sun-related behaviours rather than occupational exposure to UV light or cosmic radiation exposure.[10] They reported comparably elevated rates of melanoma among a cohort of air traffic controllers in addition to pilots and suggested that this may be due to some lifestyle similarities, such as access to holidays in sunny destinations.

However, the conclusion reached by dos Santos Silva differed from that of Rafnsson and colleagues, who had previously carried out a large observational study comparing constitutional and behavioural risk factors for melanoma between aircrew (pilots and flight attendants) and a population sample (using self-reported data from questionnaire responses).[33] While aircrew did have a higher prevalence of sunny vacations, Rafnsson and colleagues did not find any substantial difference in the prevalence of risk factors for melanoma (such as history of sunburn, sunbed usage, skin type or sunscreen used), when comparing aircrew with the general population. The authors concluded that it was unlikely that the increased incidence of melanoma in aircrew could be solely explained by excessive (non-occupational) sun exposure.

Adding to the complexities of teasing out the potential roles of occupational vs non-occupational ultraviolet radiation exposures is a study by Diffey and Roscoe published in 1990.[32] Based on data obtained using polysulphone film badges worn by pilots in flight the authors reported that occupational exposures to UV were negligible; this conclusion has often been cited by subsequent authors to discount cockpit UV exposures as playing a potential role in skin cancer risk. However, the methodology used could not measure UVA effectively as the sensitivity of the film badges was confined to wavelengths <320nm. So while this work showed that cockpit UVB exposures are negligible, (and this conclusion is supported by other subsequent research) we cannot draw any conclusions from it in regards to UVA exposures, which were very likely under-estimated. [30,34-36]

DO COMMERCIAL JET AIRCRAFT WINDSCREENS PROVIDE PILOTS WITH ADEQUATE PROTECTION FROM UVA LIGHT EXPOSURE DURING FLIGHT?

In 2007 the US Federal Aviation Authority (FAA) published the results of ground-based testing of transmittance of optical radiation through various types of disassembled aircraft windscreens.[30] Included were multi-laminate glass windscreens from 3 jet airliners, and acrylic windscreens from 2 turboprop airliners. The multi-laminate glass windscreens tested (typical of those used in large commercial jet aircraft) allowed some transmission of UVA radiation, particularly at wavelengths around 380nm. While UVB transmittance for both the glass and acrylic windscreens was reassuringly less than 1%, the transmission of UVA through glass began at 320nm and peaked at 53.5% at 380nm.

Few studies have attempted to quantify the level of UVA transmitted into the cockpit environment at altitude.[34-37] Sanlorenzo and colleagues measured UVA and UVB levels in a flying aircraft and compared them to measurements performed in a UVA tanning bed.[36] Cockpit UV measurements were taken in San Jose, California and Las Vegas, Nevada, in a general aviation turboprop aircraft with an acrylic windscreen, around midday in April, at ground level and various altitudes up to 30,000 feet. The authors concluded that, under their testing conditions, pilots flying for 56.6 minutes at 30,000 feet over Las Vegas, received the same amount of UVA ‘carcinogenic effective radiation’ as that from a 20-minute tanning bed session.

Chorley and colleagues, with a particular interest in pilot ocular exposures to UV, took inflight UV measures from five return sector European airline flights, one transatlantic flight from London and 4 helicopter flights from Aberdeen, Scotland.[34] They reported that some flights resulted in ocular exposures to the unprotected eye in excess of international occupational exposure guideline limits. There was wide variation in ocular UV dose during the flights and this was attributed to the UV radiation transmission characteristics of the windscreen as the main influence on exposure. The mean increase in UVA at altitude during airline flights was 2.4 times that of ground level. In line with the previous ground-based FAA study, Chorley found no significant UVB exposure within the cockpit. It was noted that there appeared to be significant variability in the transmission characteristics of individual windscreens, even within the same type and model of aircraft, and taking into account weather conditions, time of day and year, and flight destination. It appears that newer windscreens may be less effective at blocking UVA than older windscreens, although further testing is needed to clarify if this is the case.

Cadilhac and colleagues published results of inflight UV measurements during 14 commercial jet flights - 4 flights on Airbus and 10 flights on Boeing 777 aircraft.[35] No significant levels of UVB were detected, and no UVA on the ground or inflight in the Airbus aircraft, however UVA radiation was found in the cockpit of the Boeing 777 aircraft during flight. The levels were below the values found at ground level and were strongly reduced by use of the cockpit sun-visors. The authors concluded that their findings suggest that the increased incidence of melanoma in pilots may not be related to inflight UV radiation exposure and suggested that the previous work of Sanlorenzo and Chorley was congruent with this (which appears to be at odds with Sanlorenzo and Chorley's own conclusions about the potential significance of UVA exposures in-flight).[34,36]

Cadilhac and colleagues reported an average inflight UVA level of 0.34mW/cm^2 while Sanlorenzo reported a maximum UVA level of 0.24mW/cm^2. Chorley used differing units as his focus was on ocular UV exposures, making it difficult to compare his findings directly with those of Cadilhac and Sanlorenzo. Sanlorenzo concluded that inflight UVA exposures could play a role in the increased incidence of melanoma in pilots and called for further research across a variety of different aircraft types and flight conditions, noting that UVA levels may be considerably higher when flying over thick cloud cover or snow.

THE NEED FOR MORE COMPREHENSIVE INFLIGHT UVA MEASUREMENTS

While the cause of the increase in melanoma risk among pilots and cabin crew remains up for debate, it is clear that a more comprehensive UVA exposure assessment needs to be undertaken to determine exposure levels and whether additional abatement measures are indicated. Based on the limited inflight UV measures so far accumulated, (and the sometimes contradictory conclusions drawn), we do not have the breadth of data to make an adequate risk assessment. What is required is acquisition of a body of data across a range of flight conditions (such as varying duration, direction of flight, altitude, latitude, time of day and cloud cover) using a spectrometer and UV dosimetry badges to quantitatively assess exposures.

There is some limited evidence that individual windscreens may have different spectral transmission characteristics, even among the same aircraft type and model, (this may relate to the age of the windscreen) therefore sampling from a range of different aircraft will be necessary.[34] Southern hemisphere data is required given the lack of inflight studies from Australasia, a region with known elevated ambient UV levels. A collaborative approach, with researchers, airlines, and pilot unions working together to allow for a greater number of inflight UV measurements, would greatly assist in assessing the potential relationship between inflight UVA exposure in modern aircraft and melanoma risk in pilots.

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