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Impact of Gliding on the Prevalence of Keratinocyte Carcinoma and its Precursors: A Cross-sectional Study Among Male Pilots in Bavaria

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Skin cancer is the most common type of cancer in the fair-skinned population (1). One-third of diagnosed cases of cancer worldwide are skin cancer and this incidence has increased continuously over the last decade. Keratinocyte carcinoma (KC) is 18–20 times more frequent than melanoma (1), and a significant increase in both has been observed worldwide, as well as in Germany (1, 2). Although KC has a huge impact on societal costs and can be lethal (3, 4), cancer institutes worldwide usually do not systematically register data on KC. Therefore, incidence and prevalence rates are rare (1). Solar ultraviolet (UV) radiation is considered to be the main factor in the development of KC (5). Glider pilots are heavily exposed to solar UV radiation because they fly at altitudes of up to 5,000 m, flights that can last several hours, and lack UV protection (**Fig. 1**). At these altitudes, they are less protected from UV-B radiation due to a thinner atmosphere with reduced filtering of UV radiation (6). High levels of exposure to UV-B radiation increase the risk of photo-damage to the skin (6, 7).

Although some research has been carried out on military or commercial airplane pilots, no study has yet investigated the risk to glider pilots (8–10). The present study evaluated the prevalence of KC and its precursors in pilots of glider aircraft in Bavaria, Germany to assess the role of UV exposure at higher altitudes and the need for awareness and prevention campaigns.

PATIENTS AND METHODS

A cross-sectional study of adult pilots of glider aircraft was performed between May and July 2015. A random sample of 82 male pilots aged 18–83 years from 4 larger gliding clubs in Bavaria (Königsdorf, Erlangen, Dachau, and Unterwössen), Southern Germany participated in an on-site full-skin examination. The study was approved by the local ethics committee of the Technical University of Munich, and written informed consent was obtained from all participants prior to study inclusion. On the day of examination, every attending adult member (>18 years old) of the randomly chosen gliding clubs was invited to attend a volunteer skin cancer screening. No female pilots were included because most members of the participating gliding clubs were men. The full-body skin examination (11) was performed by an experienced dermatologist using a dermatoscope, and each participant's skin type categorized from I to VI according to Fitzpatrick. If the screening test result was abnormal, a histological examination was recommended. To determine KC, every suspicion of actinic keratosis, basal cell carcinoma, and squamous cell carcinoma was indicated as a positive test result. Prior to the skin cancer screening, all participants were given a standardized questionnaire about general personal data, their individual risk behaviour, and about their knowledge and awareness of skin cancer (Table SI[1]). Additional questions were inserted to control for bias (e.g. "How many hours do you spend outside on a usual day?"). The age of the participants was classified into the categories used by the German Centre for Cancer Registry Data. The characteristics of participants and frequencies were stratified by age group and compared using Fisher's exact test. After testing the variables from the questionnaire and skin cancer screening for significance, logistic regression models were used. All statistical analyses were performed using SAS version 9.2 software (TS1M0) (for details see Appendix S1[1]).

Fig. 1. "Selfie" taken by a glider pilot during a 5-h flight over 3,000 m above ground, illustrating typical severe UV exposure during flights (courtesy of Michael Sturm).

RESULTS

The overall prevalence of KC and its precursors in glider pilots in this study was 49% (40/82). In all affected pilots (40/40), the skin lesions were found on sites that are typically exposed during gliding, i.e. the face and back of the hands. Stratification by age showed that KC and its precursors was more prevalent in older age groups and among those with sunburn during childhood. Headgear (usually a small hat) was worn by 99% (81/82) of pilots. Almost half of pilots (48%) said that they generally use sunscreen on sunny days. According to their answers to the questionnaire, only 54% (44/81) of pilots had previously undergone a medical skin check by a dermatologist and 78% (64/82) mentioned regular self-examination. Furthermore, 74% (56/76) of participants stated that they were interested in further information about

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skin cancer and sun protection in general, especially as they relate to gliding. The prevalence of KC was higher in the groups with increased gliding experience and also increased with age. Interestingly, the darker type IV skin was the most affected, whereas the fairer-skinned pilots had a lower prevalence of KC. KC prevalence did not decrease with higher use of sun protection factor (SPF) on gliding days. Notably, 2 pilots had skin lesions highly suspicious of malignant melanoma and were referred to a dermatology department for excision, but not followed-up for this study (for complete details see Appendix SI[1]).

DISCUSSION

This study identified a high overall prevalence of KC and its precursors among glider pilots. As expected, a significant impact of age was found, consistent with previous studies (12, 13). Consistent with other studies, sunburn during childhood correlated with a higher prevalence of KC (14, 15). Almost all glider pilots stated that they wore headgear during a flight. However, the headgear consisted of a small hat covering the scalp, and sometimes the ears, but only a small part of the face. Approximately 50% of all included pilots, mean age 51 years, had never seen a dermatologist for a skin check. Keeping in mind that the currently available data on KC prevalence in the general population and outdoor professions relies on secondary data provided by insurance companies based on dermatologists' documentation, the "real" prevalence of KC may be underestimated. However, 75% of the study population requested further detailed information on skin cancer, associated risk factors, and prevention approaches. This documents the necessity of KC information campaigns and suggests that respective awareness and prevention efforts could be highly effective and lower the disease burden of KC.

A number of limitations apply due to the rather small study population ($n=82$) and the missing follow-up of histopathologic evaluations of the clinically diagnosed KC. In addition, the study could not consider how much of the UV radiation was absorbed by the canopy of the glider aircraft and how much reached the skin of the pilots. Furthermore, the time pilots spent at the airfield in general was neglected, even though it adds additional UV radiation exposure. Instead, the questionnaire captured the mean time pilots spend in the air during flights. A potential source of selection bias is the volunteer participation in skin screening. The result could be an overestimation of KC due to the participation of glider pilots who had previously detected unusual skin features. Our findings clearly suggest that glider pilots have a higher risk of KC compared with the general population (1, 2). Comparing our study findings with other results in similar contexts is difficult because of the lack of research on the risk behaviour of glider pilots. Studies and a meta-analysis assessing the risk of melanoma and KC in pilots are only available for military and turbojet aircrafts and have shown that these pilots have a higher incidence of melanoma and other skin cancers than the general population (8–10).

In conclusion, we strongly believe that prevention measures should be directed at pilots in general, and they should be invited to regular skin checks by dermatologists for the early detection of potential skin cancer. Further studies with larger cohorts, and potentially control groups, are needed to evaluate our findings and develop awareness and prevention campaigns.

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