

## Variation in daily ultraviolet radiation exposure and sun protection behaviours of melanoma survivors: an observational single-arm pilot study with a wearable sensor

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DEAR EDITOR, Melanoma survivors are at risk to develop another melanoma, and the same patterns of sun exposure that caused the initial melanoma contribute to the risk for a second melanoma.<sup>1</sup> Despite awareness of the risk of developing another melanoma and the benefit of sun protection in modifying that risk,<sup>2</sup> melanoma survivors often engage in unprotected episodes of sun exposure resulting in sunburn.<sup>3</sup> While melanoma survivors initially decrease sun exposure following diagnosis, these changes are not maintained.<sup>4</sup> This proof-of-concept study paired a wearable ultraviolet (UV) sensor with a self-report survey to explore sun protection behaviours of melanoma survivors

The recruited melanoma survivors (stages: melanoma in situ to stage IIB) consisted of 24 women and 15 men ( $n = 39$ ). They were diagnosed 4–7 years prior to enrolling in this study, had a mean age of 59 years (range 21–80) and had Fitzpatrick skin type I ( $n = 14$ ), II ( $n = 11$ ), III ( $n = 11$ ) or IV ( $n = 3$ ). An erythemally weighted UV sensor was used (Shade<sup>®</sup> model V1-00; YouV Labs Inc., New York, NY, U.S.A.), which reported UV exposure in  $\text{J m}^{-2}$  to one decimal

point.<sup>5</sup> It was worn during daylight hours outdoors for 10 days during the summer of 2017 in Chicago, Illinois. The sensor's magnetic ring requires affixation to clothing. As T-shirts are reliably worn by most individuals, participants were informed to affix the sensor on the left anterior chest near to the shoulder as shown to participants in a picture.

Participants completed the Daily Minutes of Unprotected Sun Exposure (MUSE) Inventory, a self-reported online survey of sun protection behaviours. This survey asks users to describe their level of clothing coverage across 17 body sites and sun protection behaviour (e.g. sunscreen use, shade seeking) during self-reported activities,<sup>6</sup> and to complete a sunburn experience survey. The median minimal erythema doses (MEDs) for skin types I, II, III and IV are 2.5, 2.8, 3.6 and 4.5 standard erythemal doses, respectively.<sup>7</sup> We clustered MUSE-reported events with UV exposure data derived from the sensor in instances when a user exceeded their daily MED. Northwestern University's institutional review board approved this protocol (STU00201983).

During 307 of 390 possible days, UV exposure was detected in a median of 15% [interquartile range (IQR) 9–20%] of daylight hours. Technical problems led to data failure for 13% of all participant-days (50 days). During 40 days, participants had no exposure, forgot to wear the sensor, engaged in aquatic activities or wore it inappropriately. The median UV exposure recorded over 10 days by each participant was  $24.8 \text{ J m}^{-2}$  (IQR 7.1–41.4), with a range of 1.0–

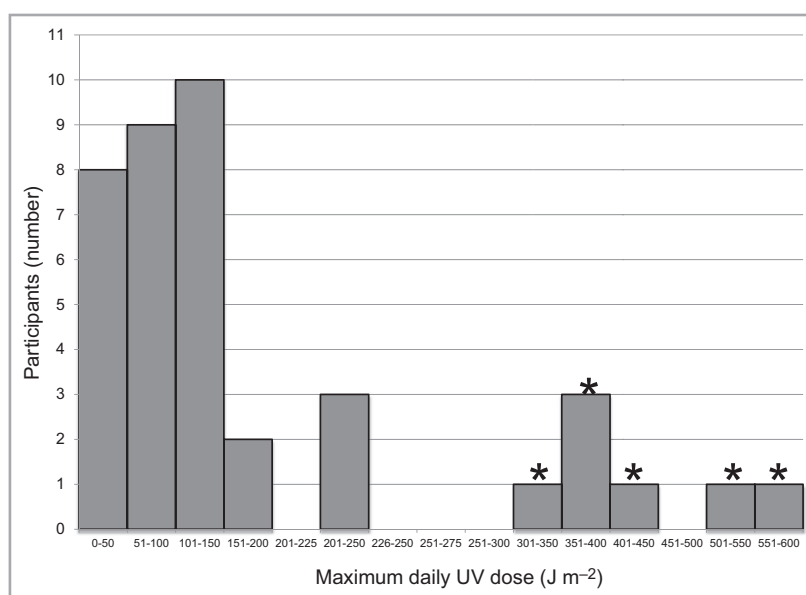


Fig 1. Maximum daily ultraviolet (UV) exposure in melanoma survivors. Participants exceeding their minimal erythema dose are indicated by an asterisk.

227.4 J m<sup>-2</sup>. The median of the maximum UV exposure recorded in a single day by each participant was 124.9 J m<sup>-2</sup> (IQR 58.6–198.7), with a range of 1.0–600.0 J m<sup>-2</sup>.

Eighteen percent of participants (seven of 39) received at least one day of UV exposure that exceeded the MED for their respective Fitzpatrick skin type (Fig. 1). For participants who exceeded their daily MED, time-paired data from the MUSE inventory and the UV sensor indicated that sunscreen use occurred in all but one of the high-exposure days (seven of eight). Sunscreen was not reapplied on 50% of the days and sunburn was reported by one volunteer who exceeded their MED and failed to reapply sunscreen. Sunglasses and hats with a rim were each worn during 50% of the UV exposure events.

During exit interviews, participants were given a report of their daily UV exposure. Five participants (13%) expressed surprise at their amount of UV exposure. All five had exceeded their MED on at least one day.

This study is limited by a small sample size and short duration of wear of the UV sensor. Furthermore, UV exposure recorded by the sensor will vary by the anatomical location of the sensor.<sup>7</sup> While participants were informed and shown where to place the sensor, daily validation of sensor placement was not performed. Additionally, the sensor was not waterproof; therefore, it was not used during aquatic activities.

While objective measures of sun exposure, such as UV dosimeters, are rarely used in either clinical or real-world scenarios, the potential benefit of a wearable UV sensor is to inform people, particularly those at risk of developing skin cancer, of their cumulative UV exposure and to alert them when they approach sufficient exposure to cause sunburn. Knowledge of personal UV exposure may improve understanding of melanoma survivors regarding the amount of sun exposure they are receiving and in what circumstances. Enhancing melanoma survivors' awareness of impending sunburn may improve adherence to sun protection in this at-risk population. With increasing ambient temperatures due to climate change, people in temperate climates may spend more days outdoors, and wearable UV sensors may help to attenuate sunburn risk.

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Conflicts of interest: none to declare.