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# Do Skin Phototypes Influence Older Adults' Well-Being? Considerations on a Novel Vulnerability to Climate-Related Factors

Laura Atzori [1,]*, Grazia Vivanet [1], Elisa Cantone [2], Michela Atzeni [2], Giulia Cossu [2], Germano Orrù [3], Alessandra Scano [3], Caterina Ferreli [1], Mauro Giovanni Carta [2] and Federica Sancassiani [2]

[1] Dermatology Unit, Department Medical Sciences and Public Health, University of Cagliari, 09124 Cagliari, Italy
[2] Department of Medical Science and Public Health, University of Cagliari, 09124 Cagliari, Italy
[3] Department of Surgical Sciences, University of Cagliari, 09124 Cagliari, Italy
* Correspondence: atzoril@unica.it

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**Abstract:** *Background*: Effects of climate changes, through higher temperatures and sunlight intensity on elderly well-being other than skin cancer, are little studied. Generally, people with fair skin is educated to avoid sun exposure, but while aging, the positive effects of natural light on social biorhythms might be important to counteract depressive symptoms. The study aimed to explore the relationship between skin phototype, social rhythm dysregulation, depressive symptoms, and quality of life in older adults on a sample of old adult residents in Sardinia (Italy). *Methods*: A cross-sectional study recruiting people aged 65 years or more, without limitation by sex, living at home. The assessments were conducted in April, which represents a month of transition and maximum change in light and temperature in central Mediterranean areas. *Results*: The study recruited 117 individuals without major diseases, voluntarily participating to an intervention for active aging. Findings suggest that individuals with lighter skin phototypes (lower than IV) experienced a higher frequency of depressive episodes and lower quality of life compared to those with darker skin phototypes. No significant differences were found in social rhythm dysregulation. *Conclusions*: The findings highlight the potential vulnerability of elderly individuals with fair skin to the combined effects of climate change and avoidance of sun exposure, emphasizing the need for further investigation. The observation raises questions of interest for the implications in terms of public health, and educational campaign contents, that should consider the age of the recipients they are aimed at.

**Keywords:** climate change; skin aging; older adults; elderly well-being; phototypes

## 1. Introduction

Human skin phototypes represent adaptations to environmental conditions, particularly solar radiation, with variations shaped by the exposure of different ethnic groups over millennia [1]. The primary role of skin pigmentation is to mediate and protect the underlying layers, especially the DNA of basal keratinocytes and cutaneous circulation from ultraviolet (UV) radiation attacks, known for their oncogenic and immunosuppressive potential. Historically, conditions of high UV exposure favored dark pigmentation as a protective mechanism during the evolution of Homo sapiens [1–3]. However, migration to temperate climates necessitated adjustments in skin pigmentation to optimize vitamin D synthesis. In these regions, individuals with less protective phototypes became more prevalent [4]. Furthermore, as prehistoric humans learned to shield themselves from environmental hazards through clothing and shelter, the evolutionary pressure for melanin production decreased [1].

Contemporary climate changes may render humans, particularly the elderly who are less adaptable, increasingly vulnerable to heat and UV radiation. Data indicate that since 1981, Italy's average temperature has increased by approximately 0.4 °C per decade (Climate-ADAPT database). Thus, alongside rising temperatures, there has been a proportional increase in sunlight intensity due to a higher frequency of sunny days. Sardinia, identified as a climate change hotspot, exemplifies these environmental pressures [5]. This demographic faces challenges in coping with rising temperatures and especially elderly may adopt avoidance behaviors.

Nevertheless, light and light pollution carry both detrimental and beneficial effects, influencing numerous health dimensions. They affect melatonin secretion and neuro-steroid activity, impacting both sexual health and mood [6,7] Additionally, light influences circadian immuno-endocrine timing mechanisms, which have evolved to optimize human behavior based on seasonal variations [8]. However, older adults experience more significant difficulties in resynchronizing their biological rhythms under modified conditions [9,10] The potential impact of climate-induced increases in sunlight exposure on the well-being of the elderly, beyond skin cancer risk, remains a relatively underexplored area. While individuals with fair skin are typically advised to minimize sun exposure due to cancer risks, the positive effects of sunlight on social biorhythms among aging populations merit consideration for mitigating depressive symptoms.

Phototype classification, based on melanin levels, determines the skin's protective capability against sun exposure and incorporates various characteristics, including eye and hair color [11]. The skin phototype classification implies that lower phototype numbers indicate a diminished ability to protect oneself from UV radiation. Individuals classified as phototype 1 must exercise extreme caution, as they are at high risk for erythema and burns. In central-southern Italy, phototype IV predominates [12]. Individuals with this phototype often exhibit olive skin tones, dark hair, and dark or hazel eyes, providing greater protection from UV exposure compared to those classified as phototypes I to III. Although less represented, elderly individuals with phototypes lighter than IV in a hot climate like Sardinia, may adopt measures to avoid heat and sun exposure. To a certain extent, educational campaign aiming to prevent skin cancers occurrence might influence also darker phototype people to avoid outdoor light pollution and consequently cause a dysregulation of biological and social rhythms—including eating, sleeping, and mood—negatively affecting their quality of life.

This study aims to investigate the interrelation between skin phototypes and the prevalence of social rhythm dysregulation in a healthy elderly population in Sardinia. Specifically, it will assess whether individuals with phototypes lower than IV exhibit a higher prevalence of depressive symptoms and a diminished perception of their quality of life.

## 2. Methods

### *2.1. Design and Setting*

This study employed an observational cross-sectional design, utilizing a sample of older adults recruited for a randomized clinical trial focused on interventions promoting active aging [13]. Inclusion criteria permitted voluntary participation without restrictions regarding gender among individuals aged 65 years or older, living at home, and otherwise healthy, without major comorbidities. Participants from the target population were recruited via public notices and volunteered to take part in the study. All participants were residents of the metropolitan area of Cagliari, a necessary inclusion criterion given that the activities were conducted frequently in the city center. As documented in the larger previous study [13,14], participants were likely to enjoy outdoor activities, including moderate exercise or cultural pursuits, and were also homogeneous in terms of years of education completed.

Assessments were conducted in April, a transitional month characterized by significant changes in light and temperature in central Mediterranean regions such as Sardinia [15].

### *2.2. Tools*

Demographic information for each participant was collected using a structured ad hoc tool.

All participants underwent a comprehensive dermatological examination, during which the dermatologist assessed their phototype using the Fitzpatrick skin type classification based on visual inspection and patient-reported history of UV exposure and tanning. Indirect markers of sun damage were registered, including sunburn spots, increased photoaging, frail skin and xerosis, history of skin cancer occurrence. The diagnostic information was thus integrated from both clinical evaluation and patient interviews to ensure accurate classification.

Social and behavioral rhythm functionality, encompassing aspects such as eating, sleeping, and social interactions, was measured via the Brief Social Rhythms Scale (BSRS) in its Italian version [16]. Elevated total

BSRS scores indicate generally poorer social and behavioral rhythm functioning. As per the supplemental literature, individuals with dysfunctional rhythms were identified as those scoring above the mean plus one standard deviation, established by a previous large sample study [10].

The screening for depressive episodes was conducted using the Patient Health Questionnaire-9 (PHQ-9) [17]. This self-administered instrument assesses the nine core depressive symptoms experienced over the past two weeks, facilitating a diagnosis of a depressive episode in accordance with DSM-5 criteria (APA, 2013). The PHQ-9 was utilized in its validated Italian version [18]. Each of the nine items is rated on a Likert scale from 0 (indicating "not at all" or minimal severity) to 4 (representing "every day" or maximum severity). A cutoff score of 4/5 demonstrates good diagnostic accuracy for identifying depressive episodes of at least mild severity [17].

The Health-Related Quality of Life Assessment was performed with the 12-item Short-Form Health Survey (SF-12), to evaluate both the physical (SF-12F) and psychological components (SF-12M) of health-related quality of life (H-QoL) [19]. The SF-12 comprises twelve items designed to measure perceived satisfaction across various aspects of daily life. Higher scores on the SF-12 indicate a better perception of health-related quality of life, whose reliability in older adults had been previously validated [20].

### *2.3. Statistical Analysis*

Descriptive analyses were conducted, presenting percentages and frequencies for nominal variables, and means (M ± SD) for continuous variables. Differences between the two groups concerning age and gender were examined. To assess the differences between study groups, one-way ANOVA was utilized for interval-scale data from non-matched samples. For nominal data, statistical evaluations were conducted using the Chi-square or Fisher's exact test. All analyses were performed using SPSS software (version 28.0.1.0, IBM, Armonk, NY, USA), with a *p*-value < 0.05 considered statistically significant.

### *2.4. Ethics*

Participants were required to provide written consent for participation after receiving comprehensive information regarding the study. It was emphasized that data would be collected and stored in an anonymous database, adhering to European data protection regulations and laws. The study was conducted in accordance with the Helsinki Declaration, with final approval of the study protocol granted by the ethics committee of the Azienda Ospedaliero Universitaria di Cagliari, Cagliari, Italy [PG/2018/15546 (approved on 25 October 2018)].

## 3. Results

The study sample comprised 117 individuals, with 85 participants classified as phototype 4 (mean age 72.18 ± 4.75 years; 22 males, 25.88%) and 32 individuals in the combined groups of phototypes 2 and 3 ($N = 22$ for phototype 3, $N = 10$ for phototype 2; mean age 72.40 ± 4.58 years; 11 males, 34.37%). The two groups were homogeneous concerning average age and gender distribution (see Table 1). Indirect markers of sun damage, including sunburn and increased photoaging, were more frequently observed in phototype 1–3 compared to phototype 4.

**Table 1.** Differences between the two groups on the variables under observation.

| | **Phototype 4 (*N* = 85)** | **Phototype 3–2 (*N* = 32)** | **ANOVA (F) (1115 df)/ Chi Square ($\chi^2$) (1 df)** | ***p*** | **OR (3 + 2) (CI 95%)** |
|---|---|---|---|---|---|
| Age | 72.18 ± 4.75 | 72.40 ± 4.58 | F = 0.051 | 0.822 | |
| Male | 22 (25.88%) | 11 (34.37%) | $\chi^2 = 0.828$ | 0.363 | |
| PHQ-9 (cut off <4) | 9 (10.6%) | 9 (28.1%) | $\chi^2 = 5.492$ | ***p* = 0.019** | **3.30 (1.17–1.30)** |
| BSRS (cut off = Mean + 1 SD) | 9 (10.6%) | 4 (12.5%) | $\chi^2 = 0.086$ | *p* = 0.769 | 1.21 (0.34–1.23) |
| SF-12 (SM) | 21.24 ± 3.52 | 19.65 ± 3.83 | **F = 4.519** | ***p* = 0.036** | |
| SF-12 (SF) | 14.11 ± 2.23 | 13.96 ± 2.09 | F = 0.051 | *p* = 0.822 | |

Legend: df = Degrees of freedom; *p* = Probability; OR = Odds Ratio; CI 95% = 95% Confidence Interval; SM = SF-12 subscale related to mental health; SF = SF-12 subscale related to physical health; F = Fisher; $\chi^2$ = Chi Square; SD = Standard deviation.

Statistical comparisons revealed significant differences in depressive symptoms, as measured by the PHQ-9, between participants with phototypes 1–3 and those with phototype 4, with a cutoff score exceeding 4. While no significant differences were detected in the BSRS means, a minimal yet statistically significant difference emerged in the SF-12 questionnaire, specifically in the mental health subscale. However, there were no statistically significant differences in the SF-12 subscale related to physical health (refer to Table 1).

## 4. Discussion

This study demonstrates that among older adults living in Sardinia, those with lower phototypes (i.e., 3 and 2) exhibit a higher frequency of unrecognized depressive episodes compared to individuals with phototype 4. Additionally, they reported lower average scores on the psychological quality of life perception questionnaire. These results are particularly relevant considering that the patients participating in the study had voluntarily agreed after reading the public advertisement and appeared to be healthier, more physically active, and more socially connected than the general elderly population. This volunteer bias is a well-known phenomenon in scientific literature on prevention-focused trials involving older adults [21]. Moreover, the preliminary recruiting interview excluded patients with overt depressive symptoms, which usually reduce a person's willingness to actively engage in demanding activities such as moderate physical exercise. The patients' interview supported a general habit to avoid sun exposure, even in darker phototype, due to the perception of the extreme climate change, with higher temperatures and sunlight pollution, together with the awareness of the risk of developing skin cancer. During the dermatologist interview, information was collected on several sun protective behaviors, including regular use of sunscreen, protective clothing, hats, and shade seeking. However, in our sample almost all patients reported engaging in these behaviors consistently. Because there was so little variation, these measures did not allow us to meaningfully distinguish between subgroups or explore dose–response relationships, and therefore they were not included in the main analyses. We now acknowledge that unmeasured or insufficiently characterized behavioral factors, may act as potential confounders. Unfortunately, we designed the data collection to be feasible within our available resources and participant burden. Accurate individual-level UV exposure and circadian rhythm assessment typically require wearable sensors (e.g., UV dosimeters, actigraphy) or sleep-wake diaries. At the time of study planning, we did not have the infrastructure, budget, ethical approval to implement these methods on a scale. Future work would clearly benefit from incorporating objective measures and detailed questionnaires.

The detection of unrecognized mood disorders, as result of a screening requires careful consideration [22]. Consequently, we defined positive results on our screener as "depressive episodes" rather than categorizing them as "major depressive disorders". A positive outcome on the screener may indicate that the person belongs to a recently identified construct termed DYMERS, or hyperactivity and rhythm dysregulation syndrome [23,24].

Although a higher frequency of individuals with dysfunctional social and behavioral rhythm functioning was observed in phototypes 2 and 3, no statistically significant differences were identified compared to phototype 4. It is important to note that the overall BSRS score, being a composite scale, is only partially influenced by the regularity of circadian biorhythms. Our findings regarding depressive episodes nevertheless suggest the need to investigate variations in melatonin and neuro-steroid rhythms across different phototypes, which could represent a relevant variable in the broader mechanism linking phototype and mood in future research. Indeed, within the spectrum of influences on internal rhythms, solar light and artificial light pollution represent significant factors [25]. Research illustrates how light regulation via circadian rhythms can impact mood and life choices, underscoring its importance amid ongoing climate changes. Notably, the Nobel Prize in Physiology and Medicine in 2017 was awarded to Hall, Rosbash, and Young for elucidating how human biological rhythms align with Earth's rhythms. Disruptions in circadian rhythms affect the sleep-wake cycle and can impede effective responses to environmental challenges [22]. Furthermore, research has suggested a connection between disturbances in circadian rhythms and cell division, potentially linking them to certain cancers [25–28].

Traditionally, within the circadian–mood axis, sleep rhythm dysregulation has been considered a factor influencing mood and is associated with fluctuations in hyperactivity and energy levels, even in the absence of overt mood disorders [29]. This framework has been linked to the concept of a bipolar spectrum, which also includes subthreshold manifestations [29–32]. However, because our study excluded individuals with major depression or bipolar disorder and focused on otherwise healthy participants, the mild depressive symptoms observed (PHQ-9 $< 4$) should be interpreted cautiously, as they may reflect subclinical variability rather than early indicators of a clinical disorder, but may instead fall within the broader bipolar spectrum and its subthreshold manifestations. Individuals on this spectrum typically appear more sensitive to disruptions in social and biological rhythms than those with other mood conditions [33–37], and environmental factors such as light pollution have been linked to a greater prevalence of subthreshold hypomanic features [38].

Further analysis, categorized by phototype, revealed no significant differences in the average scores related to physical quality of life.

A potential selection bias—rendering the findings preliminary and primarily suggestive for future evaluation—is the phototypes distribution in the overall population. While specific epidemiological data on the exact distribution of skin phototypes in the Sardinian population are limited in the literature, it is generally recognized that Sardinians tend to exhibit a higher prevalence of darker skin phototypes, such as phototype 4, due to their Mediterranean genetic heritage. This assumption is supported by regional studies on skin characteristics and the known epidemiology of skin pigmentation in Mediterranean populations, which suggest that lighter phototypes (such as 1 and 2) are less common in this area. Consequently, the predominance of phototype 4 observed in our sample aligns with ethno-geographic expectations. Given the voluntary recruitment process via public notices, we believe our sample may reasonably reflect the general skin type distribution in Sardinia. However, self-reported tendency to burn can be unreliable, and a colorimeter measurement on non-tanned skin would have provided a more objective assessment of skin color and phototype. Unfortunately, we did not have access to a colorimeter at the time of the study. Further detailed epidemiological studies should consider objective skin color measurements to address such limited evidence.

A further potential limitation of the study is that only individuals who completed the first assessment phase after enrollment in the case control study were included in the analysis. In this specific case, although the study was observational and not interventional, this bias likely led to a relatively homogeneous sample, composed predominantly of older adults with more active lifestyles, all living in a metropolitan area, socially integrated [39].

Final considerations deem with contemporary education and lifestyle changes, which have resulted in avoidance of sun exposure, particularly affecting individuals with fair skin, who are at greater risk for skin cancer. This phenomenon has been associated with the increases in bipolar disorder diagnoses in several longitudinal studies [40,41] Intriguingly, it can be viewed as paradoxical from an evolutionary perspective that skin cancer prevention could, over time exacerbate maladaptive conditions including depression. While the sample size is limited and may affect the generalizability of the findings, it should be noted that participants were recruited through public notices and voluntarily chose to participate, which may introduce a self-selection bias but also reflect spontaneous community engagement. If corroborated by further research, these findings may inform educational campaigns, particularly aimed at older adults, to not completely exclude sun exposure and implement correct outdoor activities, restore circadian rhythms and sleep quality.

In conclusion, our study, conducted with a limited sample of elderly participants using a cross-sectional design, can only yield heuristic hypotheses, however, unveil a potential vulnerability of aging individuals with fair skin to the compounded effects of climate change. Current education programs suggest limiting sun exposure due to the increased skin cancer occurrence. The perception of light pollution and extremely high temperatures increase the older adult’s tendency to remain indoors and adopt sun avoidance strategies. These observations highlight significant implications for public health engagement, the need to integrate the information conveyed by preventive campaigns explaining the positive effects of correct sun exposure, adequate outdoor activities in elderly, not undervaluing the risk of depression and isolation especially in fair skin phototypes.

## Author Contributions

L.A.: Conceptualization, Writing- final draft preparation G.V.: original draft preparation, data curation, E.C.: data curation, M.A.: data curation, G.C.: statistical analysis, draft preparation, G.O.: data curation, A.S.: data curation, C.F.: data curation, M.G.C.: Conceptualization, Methodology, F.S.: Methodology, Supervision. All authors have read and agreed to the published version of the manuscript.

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## Institutional Review Board Statement

The ethics committee of the Azienda Ospedaliero Universitaria di Cagliari, Cagliari, Italy, approved the final study protocol of the randomized clinical trial [PG/2018/15546], from which present data are extracted as sub analysis.

## Informed Consent Statement

Participants were asked to give written consent for participation to the study after information. It was also explained that the data would be collected in an anonymous database and confidentiality would respect the European data protection norms and laws. The study was carried out according to the Helsinki Declaration.

## Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Conflicts of Interest

The authors declare no conflict of interest.

## Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

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