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Last updated by author(s): Dec 9, 2025

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐	A description of all covariates tested
☐	☒	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☒	☐	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	The raw data were organized in Microsoft Excel (Microsoft Corp.). No additional custom software was used for data collection.
Data analysis	Data processing, curve fitting and statistical analysis were performed in Origin 2019(OriginLab). Image analysis, including quantification of fluorescence intensity and cell morphology, was carried out in ImageJ.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

All data supporting the findings of this study are available within the article and its supplementary files. Any additional requests for information can be directed to, and will be fulfilled by, the corresponding author. Source data are provided with this paper.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	-
Reporting on race, ethnicity, or other socially relevant groupings	-
Population characteristics	-
Recruitment	-
Ethics oversight	-

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	For the cell migration assay, six non-overlapping microscopic fields per group and time point were analysed. For the cellular senescence assay, ten non-overlapping microscopic fields per group were analysed. For both assays, cells in each experimental group were cultured in two independent wells. In the cell migration assay, three non-overlapping microscopic fields were imaged per well (two wells per group; six fields in total per time point). In the cellular senescence assay, five non-overlapping microscopic fields were imaged per well (two wells per group; ten fields in total per group).
Data exclusions	No data points were excluded from the cell migration analyses. For the cellular senescence assay, each data point was defined as the fraction of SA-β-gal-positive cells within a microscopic field; microscopic fields in which no SA-β-gal-positive cells were observed were recorded as zero in the raw dataset but were excluded from the calculation of mean values.
Replication	Cell migration and cellular senescence assays were performed in 6-well plates using hDPCs at defined passages under identical culture and illumination conditions. For each experiment, multiple non-overlapping microscopic fields were acquired per group as described in the Methods, and these fields were used for quantitative analysis (n = 6 fields per group and time point for Fig. 6d; n = 10 fields per group for Fig. 6e).
Randomization	Cells were seeded uniformly into the wells of 6-well plates. Wells were assigned to control or light-exposed groups according to the predefined plate layout and OLED characteristics. The plate layout was designed such that wells assigned to different illumination conditions were spatially separated, and the illumination pattern was restricted to the target wells so that light delivered to one group did not affect neighbouring wells or other groups.
Blinding	For the in vitro assays, quantitative analysis of cell migration and cellular senescence was performed using a predefined image-analysis workflow that processed all images in the same way without information about group allocation.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☐	☒ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☐	☒ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Eukaryotic cell lines

Policy information about cell lines and Sex and Gender in Research

Cell line source(s)	Human dermal papilla cells (hDPCs) at passages 5–13 (c-12071; PromoCell, Heidelberg, Germany) were used in this study and were cultured in Follicle Dermal Papilla Cell Growth Medium (c-26501; PromoCell) according to the manufacturer's instructions.
Authentication	The cell line had been verified repeatedly in earlier experiments performed for different projects, and no additional authentication was carried out specifically for the present study.
Mycoplasma contamination	After purchase, the cell lines were maintained in a dedicated aseptic cell culture facility following standard operating procedures to minimize microbial contamination.
Commonly misidentified lines (See ICLAC register)	No cell lines listed in the ICLAC register of commonly misidentified cell lines were used in this study.

Animals and other research organisms

Policy information about studies involving animals; ARRIVE guidelines recommended for reporting animal research, and Sex and Gender in Research

Laboratory animals	Ex vivo porcine skin membranes (Franz Cell Membrane, APURES, Republic of Korea) including the epidermis–dermis layers were used for light-transmission experiments. The membranes were derived from 6-month-old MICROPIG® (Sus scrofa domesticus; body weight 20 ± 5 kg).
Wild animals	The study did not involve wild animals.
Reporting on sex	Sex was not considered in the study design.
Field-collected samples	The study did not involve field-collected samples. All porcine skin membranes were obtained from a commercial supplier (APURES) as pre-processed products.
Ethics oversight	Only commercially available, pre-excised porcine skin membranes were used for ex vivo optical measurements, and no live animals were handled.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Plants

Seed stocks	-
Novel plant genotypes	-
Authentication	-