

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
<i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i> |
| ☒ | ☐ | 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
<i>Give P values as exact values whenever suitable.</i> |
| ☒ | ☐ | 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

NO

Data analysis

All results were derived from at least three independent experiments. Data were analyzed using Image J, Origin 2021, and GraphPad Prism 10.4.0, and presented as mean $\pm$ standard deviation (SD).

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](#)

The authors declare that all the data supporting the findings of this study are available within the article and its supplementary information. Source data are provided as a Source Data file.

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

The study did not involve human participants.

Reporting on race, ethnicity, or other socially relevant groupings

Please specify the socially constructed or socially relevant categorization variable(s) used in your manuscript and explain why they were used. Please note that such variables should not be used as proxies for other socially constructed/relevant variables (for example, race or ethnicity should not be used as a proxy for socioeconomic status).
Provide clear definitions of the relevant terms used, how they were provided (by the participants/respondents, the researchers, or third parties), and the method(s) used to classify people into the different categories (e.g. self-report, census or administrative data, social media data, etc.)
Please provide details about how you controlled for confounding variables in your analyses.

Population characteristics

Describe the covariate-relevant population characteristics of the human research participants (e.g. age, genotypic information, past and current diagnosis and treatment categories). If you filled out the behavioural & social sciences study design questions and have nothing to add here, write "See above."

Recruitment

Describe how participants were recruited. Outline any potential self-selection bias or other biases that may be present and how these are likely to impact results.

Ethics oversight

Identify the organization(s) that approved the study protocol.

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](https://www.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

Generally 2-5 independent replicates for in vitro experiments, and 6 independent biological replicates for in vivo experiments, as described in the Method and figure captions.

Data exclusions

This study did not exclude any data, and all samples were included in the analysis.

Replication

All of the studies are repeated at least third as indicated in the figure legends. All attempts at replication were successful.

Randomization

For the in vitro and in vivo experiments, the samples or animals were randomly allocated into experimental groups.

Blinding

Single-blind

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

Antibodies used

CD9 Recombinant antibody (Proteintech, Cat No. 84801-13-RR), Dilution: 1:500
 CD63 Polyclonal antibody (Proteintech, Cat No. 32604-1-AP), Dilution: 1:500
 TSG101 Recombinant antibody (Proteintech, Cat No. 84334-4-RR), Dilution: 1:5000
 Calnexin Polyclonal antibody (Proteintech, Cat No. 10427-2-AP), Dilution: 1:5000
 GAPDH Monoclonal antibody (Proteintech, Cat No. 60004-1-Ig), Dilution: 1:50000
 Anti-Rat CD90/Mouse CD90.1 Antibody[OX-7] (PE Elabscience, Catalog E-AB-F1226D
 Anti-Rat CD44H Antibody[OX-49] (APC, Elabscience, Catalog E-AB-F1225E
 Anti-Rat CD45 Antibody[OX-1] (APC, Elabscience, Catalog E-AB-F1227E
 Anti-Rat CD11b/c, PE, Catalog F3101102
 iNOS Polyclonal antibody (Proteintech, Cat No. 22226-1-AP), Dilution: 1:500
 CD86 Polyclonal antibody (Proteintech, Cat No. 30691-1-AP), Dilution: 1:500
 CD206 Recombinant antibody (Proteintech, Cat No. 83485-1-RR), Dilution: 1:500
 TGF Beta Recombinant antibody (Proteintech, Cat No. 81746-2-RR), Dilution: 1:500
 TNF-alpha Polyclonal antibody (Proteintech, Cat No. 17590-1-AP), Dilution: 1:500
 Collagen Type I Recombinant antibody (Proteintech, Cat No. 83752-5-RR), Dilution: 1:500
 Rabbit anti-SCXA Polyclonal Antibody (Absin, abs121955-100uL), Dilution: 1:500
 Rabbit anti-TNMD Polyclonal Antibody (Absin, abs155667-50uL), Dilution: 1:500
 Rabbit anti-CD31 Recombinant Monoclonal Antibody(S-R568) (Absin, abs174177-100uL), Dilution: 1:500
 Rabbit anti-YAP Polyclonal Antibody (Absin, abs133484-50ug), Dilution: 1:500
 Fibronectin Polyclonal antibody (Proteintech, Cat No. 15613-1-AP), Dilution: 1:2000
 Mmp9 Polyclonal antibody (Proteintech, Cat No. 30413-1-AP), Dilution: 1:500
 Rabbit anti-F-Actin Polyclonal Antibody (Absin, abs123596-50uL), Dilution: 1:2000
 Rabbit anti-Collagen 1α1 Polyclonal Antibody (Absin, abs147405-50uL), Dilution: 1:500
 CoraLite488-conjugated Goat Anti-Rabbit IgG(H+L) (Proteintech, Cat no : SA00013-2), Dilution: 1:500
 CoraLite594 – conjugated Goat Anti-Rabbit IgG(H+L) (Proteintech, Cat no : SA00013-4), Dilution: 1:500
 HRP-conjugated Goat Anti-Rabbit IgG(H+L) (Proteintech, Cat no : SA00001-2), Dilution: 1:10000

Validation

All antibodies are commercially available and validated by the respective manufacturers. The validation and quality control are available on the manufactures' website and datasheet. All antibodies were previously reported and routinely used for the application in this study.

CD9:
<https://www.ptgcn.com/products/CD9-Antibody-84801-13-RR.htm>
 CD63:
<https://www.ptgcn.com/products/CD63-Antibody-32604-1-AP.htm>
 TSG101:
<https://www.ptgcn.com/products/TSG101-Antibody-84334-4-RR.htm>
 Calnexin:
<https://www.ptgcn.com/products/CANX-Antibody-10427-2-AP.htm>
 GAPDH:
<https://www.ptgcn.com/products/GAPDH-Antibody-60004-1-Ig.htm>
 CD90:
https://www.elabscience.cn/p-pe_anti_rat_cd90_mouse_cd90_1_antibody_ox_7-e_ab_f1226d
 CD44:
https://www.elabscience.cn/p-apc_anti_rat_cd44h_antibody_ox_49-e_ab_f1225e
 CD45:
https://www.elabscience.cn/p-apc_anti_rat_cd45_antibody_ox_1-e_ab_f1227e
 CD11b:
<https://www.liankebio.com/product/anti-rat-cd11b-c-pe-clone-ox42-16358.html>
 iNOS:
<https://www.ptgcn.com/products/NOS2-Antibody-22226-1-AP.htm>
 CD86:
<https://www.ptgcn.com/products/B7-2-CD86-Antibody-30691-1-AP.htm>
 CD206:
<https://www.ptgcn.com/products/CD206-Antibody-83485-1-RR.htm>
 TGF Beta:
<https://www.ptgcn.com/products/TGFB1-Antibody-81746-2-RR.htm>
 TNF-alpha:
<https://www.ptgcn.com/results?category=&q=17590-1-AP&target=>
 Collagen Type I:
<https://www.ptgcn.com/products/COL1A2-Antibody-83752-5-RR.htm>
 SCX:
<https://www.absin.cn/rabbit-anti-scx-scleraxis-polyclonal-antibody/abs121955.html>
 TNMD:
<https://www.absin.cn/rabbit-anti-tnmd-polyclonal-antibody/abs155667.html>
 CD31:
[https://www.absin.cn/rabbit-anti-cd31-recombinant-monoclonal-antibody\(s-r568\)/abs174177.html](https://www.absin.cn/rabbit-anti-cd31-recombinant-monoclonal-antibody(s-r568)/abs174177.html)

YAP:
<https://www.absin.cn/rabbit-yap-polyclonal-antibody/abs133484.html>
 Fibronectin:
<https://www.ptgcn.com/products/FN1-Antibody-15613-1-AP.htm>
 Mmp9:
<https://www.ptgcn.com/products/Mmp9-Antibody-30413-1-AP.htm>
 F-Actin:
<https://www.absin.cn/rabbit-anti-f-actin-polyclonal-antibody/abs123596.html>
 Collagen 1 α 1:
<https://www.absin.cn/anti-collagen-1-alpha-1-antibody/abs147405.html>
 CoraLite488-conjugated Goat Anti-Rabbit IgG(H+L):
<https://www.ptgcn.com/products/CoraLite488-conjugated-Affinipure-Goat-Anti-Rabbit-IgG-H-L-secondary-antibody.htm>
 CoraLite594 – conjugated Goat Anti-Rabbit IgG(H+L):
<https://www.ptgcn.com/products/CoraLite594-conjugated-Goat-Anti-Rabbit-IgG-H-L.htm>
 HRP-conjugated Goat Anti-Rabbit IgG(H+L):
<https://www.ptgcn.com/products/HRP-conjugated-Affinipure-Goat-Anti-Rabbit-IgG-H-L-secondary-antibody.htm>

Eukaryotic cell lines

Policy information about [cell lines and Sex and Gender in Research](#)

Cell line source(s)	HUVEC were derived from humans, TDSCs from rats, and the remaining cells from mice.
Authentication	TDSCs were isolated from rats, while the others were purchased from biological companies.
Mycoplasma contamination	<i>Confirm that all cell lines tested negative for mycoplasma contamination OR describe the results of the testing for mycoplasma contamination OR declare that the cell lines were not tested for mycoplasma contamination.</i>
Commonly misidentified lines (See ICLAC register)	<i>Name any commonly misidentified cell lines used in the study and provide a rationale for their use.</i>

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	Healthy adult Sprague-Dawley (SD) rats (250–300 g, Shanghai Bikai Biotechnology Co., Ltd.) and Healthy adult New Zealand rabbits (2000–2500 g, Shanghai Shengwang Laboratory Animal Breeding Co., Ltd.) were housed in the animal facility of Naval Medical University.
Wild animals	The study did not involve wild animals.
Reporting on sex	The study did not intend to focus on a single sex.
Field-collected samples	The study did not involve samples collected from the field.
Ethics oversight	All animal experiments were approved by the Animal Ethics Committee of the First Affiliated Hospital of Naval Medical University (CHEC2025-017).

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

Plants

Seed stocks	The study did not involve plants.
Novel plant genotypes	<i>Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.</i>
Authentication	<i>Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosaicism, off-target gene editing) were examined.</i>

Plots

Confirm that:

- ☒ The axis labels state the marker and fluorochrome used (e.g. CD4-FITC).
- ☒ The axis scales are clearly visible. Include numbers along axes only for bottom left plot of group (a 'group' is an analysis of identical markers).
- ☒ All plots are contour plots with outliers or pseudocolor plots.
- ☒ A numerical value for number of cells or percentage (with statistics) is provided.

Methodology

Sample preparation	Treated cells were washed and stained with fluorescent probe or antibodies following the manufacturer's instructions
Instrument	BD BDLSRFortessa
Software	BD BDFACSDiva9.0andFlowjoV10.8
Cell population abundance	10,000 cells were counted and analyzed in all experiments.
Gating strategy	FSC-SSC and singlets were pre-gated.All debris was excluded.

☒ Tick this box to confirm that a figure exemplifying the gating strategy is provided in the Supplementary Information.