Supplementary Table S6. Summary of the design-specific Joanna Briggs Institute (JBI) methodological quality appraisal of the included

Study	Study design (JBI tool applied)	Main methodological strenghts identified by JBI appraisal	Main methodological concerns identified by JBI appraisal	Principal implications for interpretation
Brinkmann et al., 2021	Quasi-experimental	Standardized within-subject design; standardized OCTA assessment of retinal and choroidal perfusion before and after both exercise interventions; repeated pre–post measurements; complete follow-up; appropriate repeated-measures statistical analyses	No non-exercising concurrent control group; fixed order of interventions, with a potential order effect	The objective and standardized repeated-measures design supports interpretation of immediate within-subject changes, but the absence of a control group and possible order effects limit causal attribution of the observed changes specifically to the exercise interventions.
Cui et al., 2023	Analytical cross-sectional	Clearly defined eligibility criteria; validated exposure assessment; standardized OCTA measurements; identification and statistical adjustment for relevant confounding factors; appropriate statistical analyses	Cross-sectional design	The study provides methodologically sound evidence of associations, but temporal sequence and causality cannot be established.
Goeder et al., 2024	Randomized controlled trial	True randomization; allocation concealment; comparable groups at baseline; standardized outcome assessment; appropriate	Participants and intervention providers were not blinded, as expected for an exercise intervention; no explicit intention-to-treat analysis was reported	Randomization, allocation concealment, and standardized assessments strengthen causal interpretation, although the absence of participant/provider

		statistical analyses; prospectively registered parallel-group RCT design		blinding may introduce performance bias and the lack of an explicit intention-to-treat analysis may affect the robustness of the estimated intervention effect.
Hauser et al., 2023	Cohort	Prospective four-year follow-up; standardized and reliable assessment of cardiorespiratory fitness, retinal vessel diameters, and pulse wave velocity; appropriate mixed-effects regression and path analysis; confounder selection informed by directed acyclic graphs	Substantial attrition: 664 of 1,171 baseline participants had complete follow-up data; retained participants had higher baseline fitness than those lost to follow-up; no analysis adequately correcting for loss to follow-up was reported	The longitudinal design and robust measurements support temporal interpretation of the observed associations, but differential attrition may have introduced selection bias and reduced the representativeness of the follow-up sample.
Hua et al., 2021	Quasi-experimental	Well-controlled repeated-measures design in which participants served as their own controls; standardized exercise protocol and environmental conditions; standardized OCTA measurements before and after exercise under each mask condition; complete follow-up; appropriate within-subject statistical analyses	No separate concurrent control group	The within-subject design and objective repeated measurements support comparison between mask conditions and pre–post exercise changes, but the absence of a concurrent control group limits certainty that the observed changes were attributable solely to the intervention.
Karaküçük et al., 2021	Quasi-experimental	Clearly defined prospective pre–post design; standardized	No concurrent control group	The standardized pre–post assessment supports evaluation of changes following HIIT, but the absence of a control group reduces

		outcome assessment; appropriate statistical analyses		internal validity and limits causal attribution of the observed retinal microcirculatory changes to the intervention.
Köchli et al., 2021	Analytical cross-sectional	Large, well-characterized sample of schoolchildren; standardized and objective assessment of retinal vessel diameters and pulse wave velocity; relevant confounding factors identified and addressed using adjusted statistical models	Primary exposures, including socioeconomic status and parental lifestyle factors, were parent-reported; validation and reliability of the questionnaires were not reported for the current study	Objective outcome assessment and confounder adjustment strengthen the observed associations, but potential exposure misclassification and the cross-sectional design limit causal interpretation.
Krobot Čutura et al., 2026	Quasi-experimental	Clearly defined pre–post design; standardized outcome assessment; complete follow-up; appropriate intervention, measurement procedures, and statistical analyses	No separate control group	The standardized design and complete follow-up support interpretation of within-participant changes, but the absence of a control group limits certainty that the observed effects were caused by the intervention.
Ludyga et al., 2023	Cohort	Longitudinal four-year design; standardized and objective assessment of physical fitness, retinal vessel diameters, and cognitive performance; cross-lagged path analyses accounted for baseline outcome levels, confounding variables, and model fit	Outcomes were already present at baseline; substantial attrition, with approximately one-third of the baseline cohort absent at follow-up; potential attrition bias was not adequately explored, despite partial reporting of reasons and use of full information maximum likelihood	The longitudinal design and adjusted cross-lagged analyses strengthen temporal interpretation, but substantial loss to follow-up may have introduced attrition bias and reduced the representativeness of the final sample.

Müller et al., 2024	Cross-sectional + randomized controlled trial (RCT component appraised)	Prospective registration; published study protocol; standardized and blinded outcome assessment; predefined sample size calculation; appropriate statistical analyses	Allocation concealment was not clearly established; uncertainty regarding whether analyses followed the intention-to-treat principle	The publication includes a cross-sectional comparison and a randomized exercise intervention; the JBI RCT appraisal applies to the randomized intervention component. Blinded, standardized outcome assessment strengthens causal interpretation of the intervention component, although unclear allocation concealment and uncertain intention-to-treat analysis introduce some residual risk of bias.
Saloň et al., 2025	Randomized controlled trial	Appropriate parallel-group randomized design; standardized intervention protocols; blinded retinal image assessment; appropriate statistical analyses	High proportion of missing retinal outcome data; complete-case rather than intention-to-treat analyses	The randomized design and blinded image assessment strengthen internal validity, but substantial missing outcome data and complete-case analysis increase the risk of attrition bias and may affect the estimated intervention effects.
Simms et al., 2024 (Study 1)	Randomized controlled trial	Randomized parallel-group design with a relevant control group; standardized OCTA outcome assessment	Randomization and allocation-concealment procedures not described; participant and intervention-provider blinding not feasible; outcome-assessor blinding not reported; intention-to-treat analysis not explicitly stated; possible failure to account for correlation between both eyes	The design directly addresses the review question, but incomplete reporting of randomization and blinding, together with a possible unit-of-analysis error, reduces confidence in the precision and internal validity of the findings. Although significant within-group reductions were reported, no statistically significant between-group intervention effect was demonstrated; therefore, causal interpretation of the observed

				retinal changes should be made cautiously.
Simms et al., 2024 (Study 2)	Randomized controlled trial	Randomized parallel-group design; standardized OCTA measurements	Insufficient reporting of randomization, allocation concealment, and outcome-assessor blinding; statistical analysis may not have accounted for inclusion of both eyes from each participant	Standardized OCTA assessment supports outcome measurement, but unclear allocation procedures and a possible unit-of-analysis error may introduce selection bias and underestimate statistical uncertainty. No statistically significant changes in choriocapillaris density were observed in either group, and no significant between-group intervention effect was demonstrated.
Streese et al., 2023	Randomized controlled trial	Randomization; standardized outcome assessment; balanced follow-up; appropriate statistical analyses	Allocation concealment not reported; participants and intervention providers could not be blinded; outcome-assessor blinding not reported; intention-to-treat analysis not explicitly stated	The randomized design, balanced follow-up, and appropriate analyses provide relatively robust evidence, although incomplete reporting of concealment, blinding, and analysis strategy leaves some residual risk of bias.
Triantafyllou et al., 2022	Analytical cross-sectional	Participants classified using standardized diagnostic criteria; outcomes measured using validated techniques; important confounding factors identified and statistically controlled; appropriate statistical analyses	Cross-sectional design	The robust exposure and outcome assessment supports the validity of the observed associations, but temporal sequence and causal relationships cannot be established.
Twerenbold et al., 2023	Randomized controlled trial	Appropriate randomization; comparable baseline	Participants and intervention providers could not be blinded;	Randomization, baseline comparability, and blinded outcome assessment strengthen

		characteristics; blinded outcome assessors; standardized outcome measurements	allocation concealment procedure not clearly described; intention-to-treat analysis not explicitly reported	causal interpretation, but unclear allocation concealment and the absence of an explicitly reported intention-to-treat analysis leave some residual risk of selection and analysis bias.
Vieversytė-Dvylienė et al., 2026	Quasi-experimental	Standardized intervention and outcome assessment; retinal vascular outcomes measured using validated methods; independent blinded graders; repeated pre–post measurements; complete follow-up without missing data; appropriate statistical analyses	No non-exercising control group	The standardized protocol, blinded grading, and complete repeated measurements support reliable assessment of within-participant changes, but the absence of a control group limits causal attribution of those changes specifically to the intervention.
Xiang et al., 2025	Cohort	Large prospective cohort; standardized retinal imaging; appropriate multivariable adjustment; robust statistical analyses	Physical activity assessed by self-report; incomplete follow-up; no formal handling of missing data; attrition analysis not reported	The large longitudinal sample and adjusted analyses support the observed prospective associations, but exposure misclassification and unaddressed loss to follow-up may introduce measurement and attrition bias.
Yu et al., 2025	Randomized controlled trial	Appropriate crossover design; randomized intervention sequence; washout period of at least seven days; standardized outcome assessment; complete follow-up	Allocation concealment and outcome-assessor blinding not explicitly described	The randomized crossover design and washout period strengthen within-participant comparisons and reduce carry-over effects, although incomplete reporting of allocation concealment and assessor blinding leaves some uncertainty regarding risk of bias.

Żmijewska et al., 2024	Quasi-experimental	Clearly defined pre–post design; standardized exercise testing and retinal imaging; validated adaptive optics retinal imaging under standardized conditions; appropriate statistical analyses	No concurrent control group	Standardized pre–post assessment supports evaluation of acute retinal changes following exercise, but the absence of a concurrent control group limits causal inference and the ability to exclude alternative explanations for the observed changes.
Jiang et al., 2025	Quasi-experimental	Prospective 24-week intervention; multimodal OCTA/RFI assessment; standardized retinal and cognitive outcomes; longitudinal within-participant analysis.	Small sample; no non-exercise control group; correlational analyses between changes in retinal and cognitive measures; report overlaps with the same PD-yoga program.	The longitudinal multimodal assessment supports detection of within-participant change, but the small uncontrolled and overlapping cohort limits causal attribution and independent replication.
Hoover et al., 2026	Quasi-experimental	Prospective 6-month intervention; multimodal retinal neurovascular imaging; repeated longitudinal measurements within a clinically defined Parkinson's disease cohort.	Small number of completers; no non-exercise control group; complementary report from the same underlying PD-yoga program.	The study adds longitudinal neurovascular information, but findings should be interpreted as complementary within-cohort evidence rather than an independent exercise effect.
Alten et al., 2021	Cohort	Analysis of two prospectively studied HIIT cohorts; standardized OCTA acquisition; comparison of healthy adults and participants with T1DM; assessment of group-by-time effects.	Retrospective secondary analysis; small groups; non-randomized cohorts; possible baseline differences and residual confounding.	The comparative analysis supports differential choriocapillaris responses by metabolic status, but the secondary non-randomized design limits causal inference.
Wefelnberg et al., 2026	Quasi-experimental	Prospective comparative acute-exercise design; standardized single-session HIIT; OCTA with systematic quantitative analysis;	Small sample; no non-exercising concurrent control; cancer treatment and clinical heterogeneity may confound group differences.	Objective repeated measurements support an acute physiological response, but small samples and clinical differences limit

		repeated pre–post measurements in patients and healthy controls.		generalizability and attribution solely to exercise.
Wan et al., 2025	Quasi-experimental	Prospective 24-week supervised yoga intervention; standardized OCTA assessment; longitudinal analysis and prespecified clinical characterization of Parkinson's disease.	Small completer sample; no non-exercise control; subgroup analyses were exploratory; overlapping PD-yoga cohort.	The study supports assessment of longitudinal CCD change, but null overall findings and exploratory subgroup results require cautious interpretation and independent replication.
Luo et al., 2026	Analytical cross-sectional	Objective wrist-actigraphy combined with questionnaire-based physical activity assessment; standardized SS-OCTA; multivariable adjustment; clinically characterized POAG and control groups.	Cross-sectional design; modest sample; residual confounding and reverse causation remain possible.	Adjusted associations support a relationship between habitual activity and choroidal circulation, but temporal sequence and causality cannot be established.
Petersen et al., 2022	Quasi-experimental	Standardized acute isometric stimulus and flicker testing; objective retinal arteriolar video analysis; Fourier-based vasomotion assessment; within-participant physiological measurements.	Secondary analysis of previously recorded data; no non-exercising concurrent control; potential multiple-comparison/exploratory-analysis concerns.	The physiological design supports characterization of acute autoregulatory responses, but the secondary uncontrolled analysis limits causal certainty.
Fang et al., 2021	Analytical cross-sectional	Objective exercise-based fitness assessment; standardized OCTA; clearly defined cognitively normal older-adult sample; retinal and cognitive outcomes assessed with established methods.	Small sample; cross-sectional design; limited statistical power and potential residual confounding.	The null fitness–retinal density association is informative, but the small cross-sectional sample limits precision and excludes causal interpretation.
Jiang et al., 2023	Quasi-experimental	Prospective controlled 8-week HSCT intervention; non-training comparison group;	Very small sample; allocation was not randomized; limited information	The controlled longitudinal design supports a training-related signal, but small non-randomized groups

		standardized RFI/OCTA assessment; objective retinal capillary-function outcome.	on blinding; overlaps with other 8-week Miami HSCT publications.	and cohort overlap limit precision and independent replication.
Gameiro et al., 2025	Randomized controlled trial	Randomized allocation between two structured yoga modalities; 24-week supervised intervention; multimodal retinal imaging; standardized repeated outcome assessment.	No non-exercise control group; small sample; both groups received active exercise; inability to isolate exercise from time or repeated-measure effects.	Randomization supports comparison between yoga modalities, but without a non-exercise control the observed longitudinal changes cannot be attributed definitively to exercise itself.
Uğurlu & İçel, 2021	Analytical cross-sectional	Clearly defined athlete and nonathlete groups; standardized SD-OCT/OCTA measurements; multiple retinal and peripapillary vascular outcomes.	Cross-sectional design; athlete status may be associated with unmeasured lifestyle or physiological differences; limited ability to establish temporality.	The study demonstrates group differences in retinal microvascular phenotype, but selection effects and residual confounding preclude causal attribution to regular physical activity.
Nie et al., 2022	Quasi-experimental	Prospective repeated-measures acute-exercise protocol; standardized running stimulus; OCTA assessment before and during recovery; inclusion of POAG and normal participants.	Small groups; no non-exercising concurrent control; repeated ocular measurements may be sensitive to image quality and segmentation; limited power for subgroup comparisons.	The design supports characterization of short-term regional perfusion responses, but the absence of a concurrent control and small sample limit causal and subgroup conclusions.
Li et al., 2021	Quasi-experimental	Standardized cycling protocol; repeated SS-OCT/SS-OCTA measurements; comparison of myopic and emmetropic children; assessment of multiple retinal and choroidal vascular compartments.	Small emmetropic comparison group; no non-exercising control; multiple retinal outcomes and time points; potential influence of refractive/anatomical differences.	The repeated-measures design supports transient exercise-related changes, but group imbalance and refractive-status differences require cautious interpretation.
Zhang et al., 2021	Quasi-experimental	Prospective 8-week HSCT study with non-training controls; standardized Retinal Function Imager assessment; objective	Very small sample; non-randomized allocation; limited blinding information; complementary report	The controlled prospective design supports a possible training-related increase in retinal tissue perfusion, but small non-

		retinal tissue-perfusion outcome and cognitive testing.	from the same 8-week Miami HSCT cohort.	randomized groups and cohort overlap limit generalizability.
Drachmann et al., 2023	Quasi-experimental	Standardized isometric exercise; combined retinal oximetry and Doppler OCT; repeated regional measurements of oxygen saturation, vessel diameter, and blood flow.	No non-exercising control group; modest sample; acute laboratory findings may not generalize to other exercise modalities or populations.	The multimodal physiological assessment provides strong within-participant evidence of region-specific acute responses, but it does not establish longer-term adaptation.
Liang et al., 2024	Quasi-experimental	Prospective repeated-measures design; standardized exercise intensity; comparison across no-mask, surgical-mask, and N95 conditions; SS-OCTA assessment with recovery measurements.	No non-exercising concurrent control; modest sample; multiple conditions and vascular outcomes increase multiplicity; mask order/randomization details may affect interpretation.	The repeated measurements support transient post-exercise vascular changes and recovery, but the uncontrolled design and multiple comparisons limit causal certainty.
Ikemura et al., 2022	Quasi-experimental	Standardized moderate cycling protocol; objective laser-speckle flowgraphy; repeated post-exercise and recovery assessments; inclusion of younger and older adults.	Exercise experiment included men only; no non-exercising control; some ocular measurements were unavailable because of blinking or insufficient pupil diameter.	The physiological protocol supports the finding of unchanged retinal arteriolar stiffness despite systemic changes, but sex restriction and missing ocular measurements limit generalizability.
Mauget-Faÿsse et al., 2021	Quasi-experimental	Real-world prospective pre–post marathon design; multimodal fundus/OCT/OCTA assessment; standardized post-race evaluation; high completion of post-race assessment.	No concurrent control group; exercise exposure was prolonged and uncontrolled in real-world conditions; hydration and systemic physiological changes may confound retinal findings.	The study captures ecologically valid responses to endurance exercise, but the uncontrolled pre–post design cannot separate exercise effects from dehydration and other race-related factors.
Zhou et al., 2025	Randomized controlled trial	Randomized HSCT and control groups; 24-week intervention; standardized OCTA assessment; explicit between-group comparison;	Small sample; randomization/allocation-concealment and assessor-blinding details were incompletely reported;	The controlled design supports the null CCD finding, but limited sample size and overlapping cohort evidence constrain

		complementary analysis of a defined retinal outcome.	complementary publication from the Miami HSCT cohort.	precision and independent replication.
Bek & Jeppesen, 2021	Quasi-experimental	Standardized isometric exercise; retinal oximetry with regional macular and peripheral assessment; repeated within-participant measurements of oxygen extraction and vessel diameter.	Small sample; no non-exercising control; acute physiological design; limited range of retinal outcomes.	The study supports a region-specific acute metabolic response, but the uncontrolled design limits causal attribution and does not inform chronic adaptation.
Ben Aoun et al., 2025	Quasi-experimental	Prospective pre–post exercise-stress testing in a clinically relevant angina population; standardized OCTA; assessment of superficial, deep, and choriocapillaris compartments.	Small clinical sample; no healthy or non-exercising control group; analysis included eyes rather than clearly independent participants, raising possible unit-of-analysis concerns.	The study suggests an acute DCP response to exercise stress in effort angina, but the uncontrolled design and possible eye-level clustering limit causal and prognostic interpretation.
Liang et al., 2025	Analytical cross-sectional	Objective 7-day accelerometer-based step assessment; standardized OCTA of optic-disc vessel density; multivariable adjustment for relevant covariates.	Cross-sectional design; modest POAG sample; both eyes were included for some participants and dependence between eyes requires appropriate statistical handling; residual confounding remains possible.	The adjusted association between daily steps and optic-disc vessel density is hypothesis-supporting, but temporality and causality cannot be established.

Abbreviations: JBI, Joanna Briggs Institute; OCTA, optical coherence tomography angiography. Complete item-level methodological appraisals using the appropriate design-specific JBI Critical Appraisal Tools are provided in Supplementary File S4. Supplementary Table S3 summarizes the principal methodological strengths, limitations, and their implications for the interpretation of each included study.