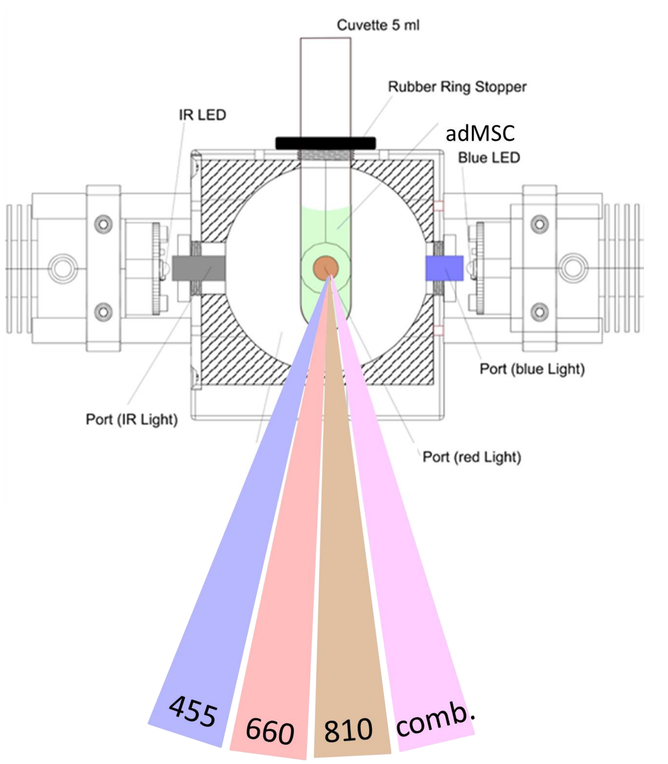
Enhancing regenerative potential: effects of light exposure on adipose-derived mesenchymal stem/stromal cells in vitro

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Introduction

Light of different wavelengths can modulate cellular behavior and metabolic pathways, with promising applications in regenerative medicine. When applied therapeutically to modulate cellular responses, this process is called photobiomodulation. The modulation of cellular processes is harnessed through targeted illumination, yet wavelength-dependent cellular responses remain incompletely understood, especially in human adipose-derived mesenchymal stem/stromal cells (adMSCs). We therefore aimed to systematically investigate how different light wavelengths influence the viability, function, and differentiation of adMSCs to optimize their regenerative potential.



Results

Immediate Effects

Reactive Oxygen Species (ROS)

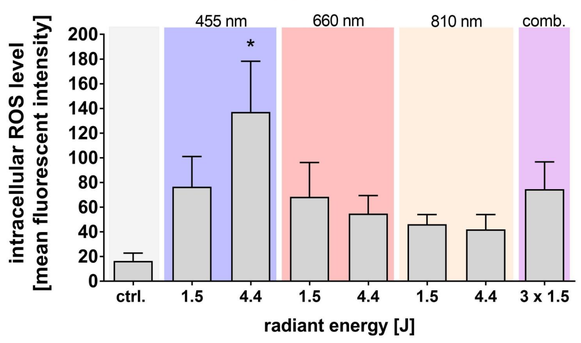


Figure 1: Quantification of intracellular ROS immediately after light exposure. Comparisons vs. untreated controls (ctrl.); significance (* $p \leq 0.05$); $n \geq 3$.

Cell Number

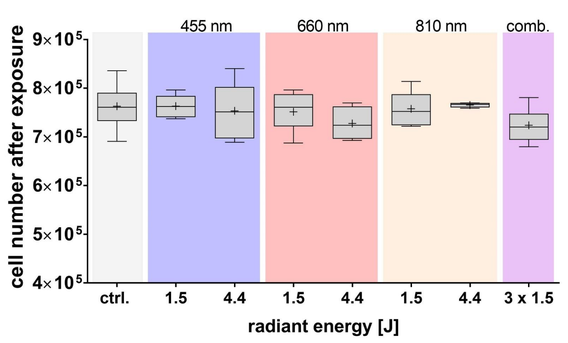


Figure 2: Analysis of cell number of adMSCs immediately after light exposure. Comparisons vs. untreated controls (ctrl.); significance (* $p \leq 0.05$): not significant; $n \geq 3$.

Viability

Table 1: Cell viability immediately after light exposure at different wavelengths; $n \geq 3$.

Wavelength [nm]	Radiant Energy [J]	Viability [%] Mean ± SD
Control	-	94.09 ± 3.70
455 Blue	1.45	94.98 ± 2.05
	4.35	95.65 ± 2.20
660 Red	1.45	92.84 ± 3.54
	4.35	92.83 ± 2.42
810 NIR	1.45	94.69 ± 2.07
	4.35	92.64 ± 2.10
455 – 810 Combined	3 x 1.45	92.15 ± 0.85

Prolonged Effects

Proliferation

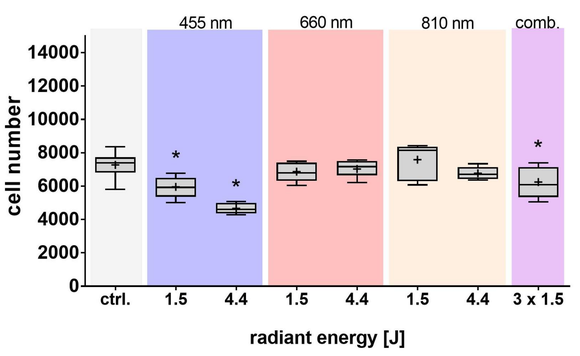


Figure 3: Determination of cell number of adMSCs 24 hours after light exposure. Comparisons vs. untreated controls (ctrl.); significance (* $p \leq 0.05$); $n \geq 3$.

Metabolic Activity

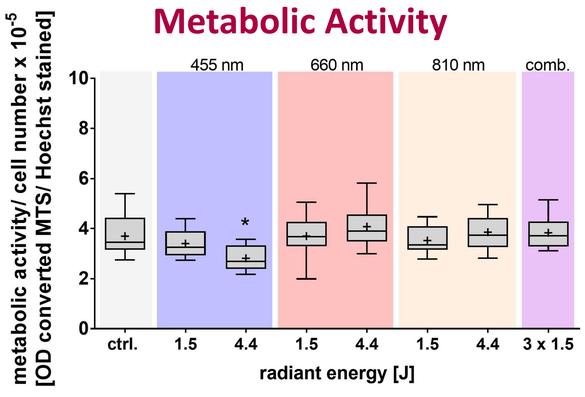


Figure 4: Quantification of metabolic activity 24 hours after light exposure. Comparisons vs. untreated ctrl.; significance (* $p \leq 0.05$); $n \geq 3$.

Energy Metabolism

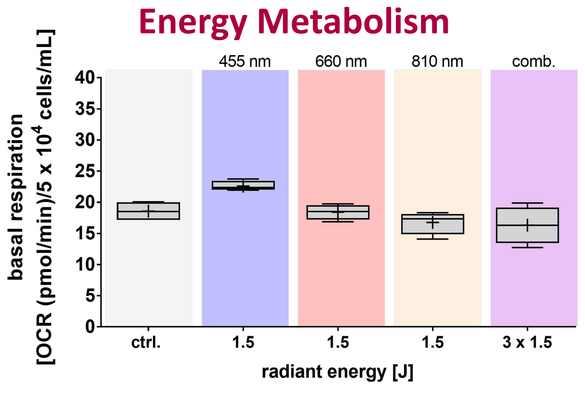


Figure 5: Analysis of the basal oxygen consumption rate 24 hours after light exposure. Comparisons vs. untreated ctrl.; significance (* $p \leq 0.05$); $n \geq 3$.

Migration

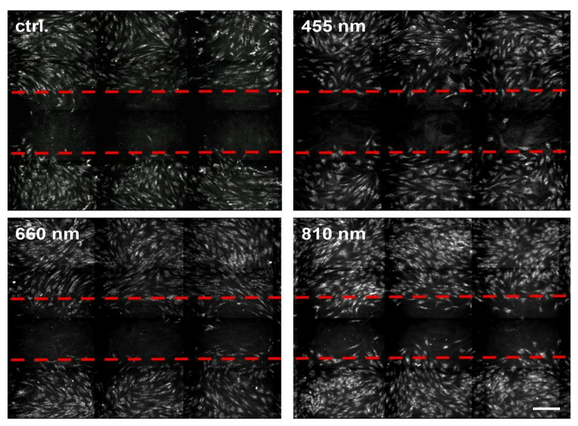


Figure 6: Impact of light exposure on the migratory activity of adMSCs 15 hours after scratching. Comparisons vs. ctrl.; significance (* $p \leq 0.05$); $n \geq 3$.

Adipogenic Differentiation

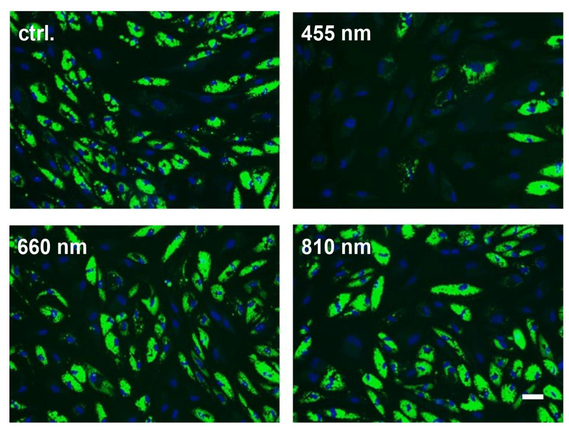


Figure 7: Effects on adipogenic differentiation of adMSCs 17 days after light exposure. Comparisons vs. ctrl.; significance (* $p \leq 0.05$); $n \geq 3$.

Summary

455 nm (blue):
- intracellular ROS ↑
- proliferation, metabolic activity, IL-6/IL-8 secretion and differentiation potential ↓

660/810 nm (red/NIR):
- full viability
- mitochondrial and migratory activity ↑

Conclusion

Light exposure induced wavelength-specific effects in adMSC: red/NIR light promoted regenerative responses, blue light induced cellular stress; in vivo relevance requires further study.

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