HARMFUL EFFECTS OF SCREEN-EMITTED ARTIFICIAL VISIBLE LIGHT IN DERMIS: AN ADDITIONAL ENVIRONMENTAL STRESS NOT TO BE NEGLECTED

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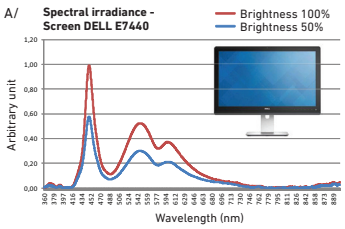
INTRODUCTION

- Artificial visible light is everywhere in our modern life. Daily use of electronic devices (cell phones, computers, tablets and TV) leads to increasing exposure to LED sources emitting in visible light wavelengths. Even if the amounts of energy emitted by electronic devices are weak, the users are very close to the light source and spend a lot of time in front of screens.
- For the first time, we have precisely characterized the screen-emitted artificial visible light and then developed a unique equipment accurately recreating the characteristic light emitted by screens.
- In this study, we have investigated the effects of such a light in human dermal fibroblasts and we described a patented plant extract of *Withania somnifera* (WSE) root able to protect fibroblasts against the harmful effects of screen-emitted artificial light.

RESULTS

Development of equipment to accurately mimic the artificial visible light emitted by screens of electronic devices

A/



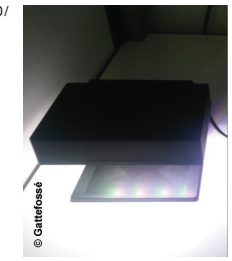
B/

Screen	Dominant Wavelength (nm)		
Apple iPhone 4S	448	529	588
Apple iPhone 5S	450	537	600
Samsung Galaxy S4	450	520	613
Apple iPAD 2	446	537	604
Samsung Galaxy Tab	449	535	592
Samsung Galaxy Note2	448	532	592
Screen DELL U2312MHT	447	539	600
Screen DELL E7440	448	548	599
Mean	448	535	599

C/

Screen	Spectral irradiance (µW/cm²)							
	Blue light (400-490nm)		Green Light (490-577nm)		Red light (577-700nm)		TOTAL (400-700nm)	
	Brightness 50%	Brightness 100%	Brightness 50%	Brightness 100%	Brightness 50%	Brightness 100%	Brightness 50%	Brightness 100%
Apple iPhone 4S	14,54	38,66	15,06	44,15	13,63	35,8	43,24	118,61
Apple iPhone 5S	15,3	40,82	13,98	43,22	14,49	39,72	43,76	123,76
Samsung Galaxy S4	13,56	38,24	14,32	44,14	14,69	41,63	42,58	124,01
Apple iPAD 2	15,63	47,4	15,01	56,21	14,21	44,63	44,85	148,24
Samsung Galaxy Tab	21,25	39,69	23,24	46,48	21,45	40,69	65,95	126,86
Samsung Galaxy Note2	19,78	29,39	20,79	32,89	19,27	28,95	59,84	91,23
Screen DELL U2312MHT	20,52	29,61	22,26	33,41	22,23	32,31	65,01	95,33
Screen DELL E7440	15,29	25,51	17,51	30,42	15,04	25,15	47,84	81,09
Mean	16,98	36,17	17,77	41,37	16,88	36,11	51,63	113,64

D/

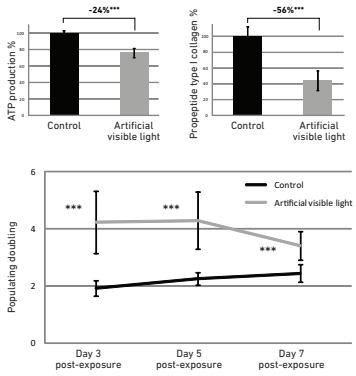


Physical characteristics of the artificial visible light emitted by screens of electronic devices:
A- Spectrum of artificial visible light emitted by the DELL E7440 screen
B- 3 dominant wavelengths in blue (~448nm), green (~535 nm) and red (~599) colors whatever the screens
C- Spectral irradiances of artificial visible light of screens are roughly similar. Spectral irradiances of blue, green and red lights are also approximately the same for all screens

D- Equipment mimicking the artificial visible light emitted by screens:
• 36 LED simultaneously emitting blue (450 nm), green (525 nm) and red (625 nm) lights at distinct wavelengths with narrow spectrum and delivering an equivalent radiant power for the three colors
• For this study, the equipment was calibrated to emit 99 J/cm² of visible light corresponding to 33 J/cm² of blue light + 33 J/cm² of green light + 33 J/cm² of red light

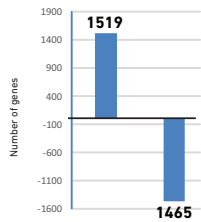
Tremendous detrimental effects of artificial visible light in human dermal fibroblasts

Cell, matrix and biochemical damage



After artificial visible light exposure, cell viability was not impacted (data not shown) but human dermal fibroblasts displayed a phenotype similar to that of aged cells

Genomic damage
Human genome microarray-based gene expression



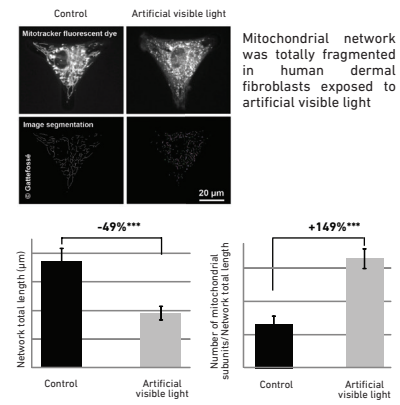
Gene deregulation after light exposure:
n=3 donors (21 ± 3 yo)
Fold Change > 1.5
P-value ≤ 5E-02

More than 8% of genes (2,984 out of 35,000) of the whole genome had a deregulated expression in fibroblasts exposed to artificial visible light

Functional annotation of deregulated genes using INGENUITY pathway analysis		
Top canonical pathways	P-value	Overlap
Mitochondrial Dysfunction	2,44E-08	43/171
Integrin Signaling	3,38E-05	37/186

Molecular pathways related to Mitochondria and Cell Cytoskeleton were highly deregulated in human dermal fibroblasts exposed to artificial visible light

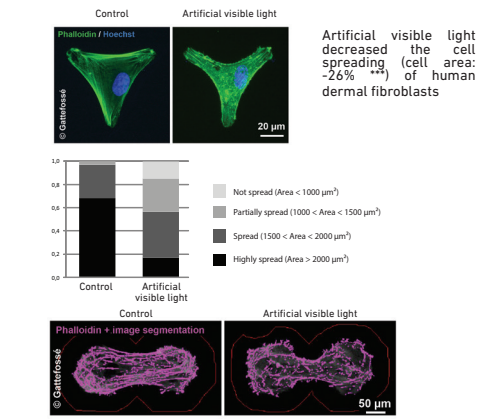
Mitochondrial damage



Mitochondrial network was totally fragmented in human dermal fibroblasts exposed to artificial visible light

As a result, the total length of mitochondrial network decreased and the number of mitochondrial subunits increased

Cell spreading damage

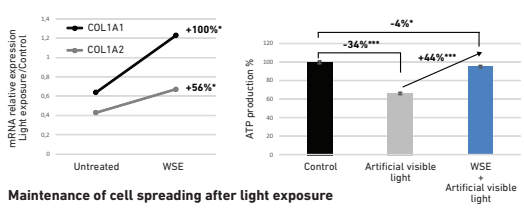


Artificial visible light decreased the cell spreading (cell area: -26% ***) of human dermal fibroblasts

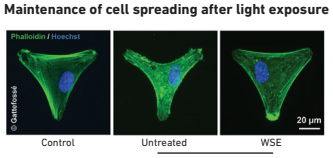
Artificial visible light disorganized the stress fibers (fiber density: -35% ***; fiber alignment: -21%***)

Withania somnifera extract (WSE) protects human dermal fibroblasts against artificial visible light

Maintenance of matrix synthesis and ATP production after light exposure



Maintenance of cell spreading after light exposure

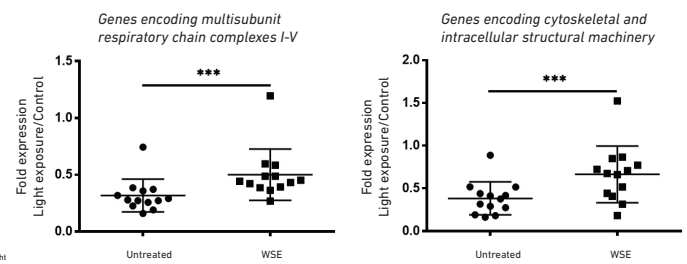


Cell spreading %:
(cell area > 1500 µm²)

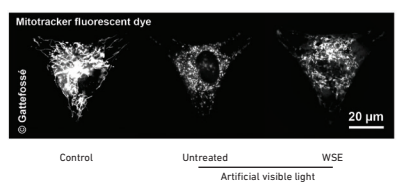
• +38% **** WSE_{Light} *vs.* $Untreated_{Light}$

• Not significant:
Control *vs.* WSE_{Light}

Protection of expression of genes related to Mitochondria and Cell Cytoskeleton after light exposure



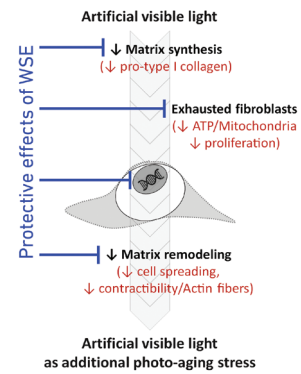
Protection of mitochondria after light exposure



Network total length:
• +35% **** WSE_{Light} *vs.* $Untreated_{Light}$

Mitochondrial subunit number:
• -20% ** WSE_{Light} *vs.* $Untreated_{Light}$

Take-home message



CONCLUSION

Following artificial visible light exposure:

- Transcriptome response is strongly induced in human dermal fibroblasts
- Mitochondrial function (i.e. mitochondrial network fragmented) is impaired resulting in cells losing capacity to produce energy
- Cell cytoskeleton (i.e. stress fibers disorganized) is damaged causing reducwed cell spreading and contractibility
- Human dermal fibroblasts display a phenotype (i.e. low proliferative rate and reduced ECM synthesis) close to that of aged cells
- *Withania somnifera* extract effectively protects against damage induced by artificial visible light