The impact of ageing and chronic sun exposure on the biomechanical function and histological composition of black African-American skin

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INTRODUCTION

Human skin offers protection against external mechanical trauma via the reversible deformation of its structure [1]; the components of the dermal extracellular matrix (ECM) help imbue skin with these important biomechanical properties. In lightly pigmented skin (Fitzpatrick phototype I-III), intrinsic ageing and chronic exposure to solar ultraviolet light are well characterised and result in complex skin changes that affect the integrity of the ECM and impact the biomechanical properties of skin [2]. The effect of intrinsic ageing and chronic sun exposure on the histological composition of highly pigmented skin (phototype V-VI) is less well characterised; and the impact of these factors on the biomechanical function is currently unknown.

AIM

To characterise the consequences of intrinsic ageing and chronic sun exposure on the biomechanical properties of black African-American skin (phototype V-VI) and relate these findings to underlying histological skin architecture.

METHODS

Healthy, black African-American (Fitzpatrick phototype V-VI; young: 18-30 years, n = 21; old: >65 years, n = 18) volunteers were recruited to the study. Gross mechanical testing was performed using a Cutometer® MPA580 (4 mm aperture probe; mode 1:3 second suction, 3 second relaxation for 10 cycles using a negative pressure of 450 mbar; figure 1) on the buttock and dorsal aspect of the forearm. Skin biopsies (6mm) were obtained from all volunteers, at both test sites, and processed for histological investigation.

Figure 1. Measurement of biomechanical properties of the skin
Graphical representation of the biomechanical properties obtained from application of the Cutometer® in mode 1 (a). Absolute parameter values generated from time-strain curves are used to calculate R-parameters which describe a variety of biomechanical properties (b).

RESULTS

1. Intrinsic ageing and chronic sun exposure compromise the biomechanical properties of black African-American skin

Healthy, young buttock and forearm skin has similar biomechanical properties; it is resilient (capable of returning to its original position following deformation; R1), exhibits minimal fatigue (R4) and is highly elastic (R2, R5 and R7).

Figure 2. Graphs depicting cutometry for buttock (a) and forearm (b) of black African-American skin from young (solid lines) and old (dotted lines) subjects

The ability of intrinsically aged skin to be deformed (Ue and R0) is not significantly different to young buttock skin. However, elasticity (R2, R5 and R7) and the ability of skin to return to it's original position (R1) are significantly impaired ($P < 0.01$) and signs of fatigue are apparent (R4; $P < 0.01$).

Despite no difference in the ability of aged forearm to be deformed (R0), chronic sun exposure significantly impairs all other biomechanical properties ($P < 0.001$).

2. Effacement of the rete ridges is exacerbated by chronic sun-exposure

Analysis of epidermal morphology identified a significant reduction in epidermal thickness in both intrinsically aged and sun-exposed phototype V-VI skin ($P < 0.001$). A modest reduction in dermal-epidermal junction convolution is apparent in intrinsically aged skin ($p < 0.05$); however chronic sun exposure causes marked effacement of the rete ridges ($P < 0.001$).

Figure 3. Haematoxylin and eosin staining of young (a) and intrinsically aged (b) buttock skin and young (c) and old (d) sun-exposed forearm. Graphs of epidermal thickness (e) and DEJ convolution (f) demonstrate significant differences with intrinsic ageing and chronic sun-exposure.

3. Elastic fibre network components are significantly reduced in both intrinsically aged and chronically sun-exposed skin

Candelabra-like arrays of fibrillin-rich microfibrils are significantly reduced in both intrinsically aged and sun-exposed skin ($P < 0.001$).

Figure 4. Immunohistochemical staining of fibrillin-rich microfibrils identified significant reduction in the overall abundance of these fibres in intrinsically aged skin (a, b & e) and chronically sun-exposed skin (c, d & e), as compared to young skin.

Discrete cascades of elastin-positive fibres confer elastic recoil to the dermis and are significantly depleted in chronically sun-exposed skin ($P < 0.001$) but not intrinsically aged skin.

Figure 5. Immunohistochemical staining of mature elastin identified significant reduction in the overall abundance of these fibres in chronically sun-exposed skin (c, d & e) but not in intrinsically aged skin (a, b & e).

CONCLUSIONS

- This study identifies that disruption to the highly organised elastic fibre network and effacement of the rete ridge structure in aged black African-American forearm and buttock coincides with a marked decline in biomechanical function;
- We conclude that in skin of colour, despite the photoprotective properties of melanin, chronic sun exposure exacerbates skin ageing at both the histological and functional level.

References:

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