The influence of age and sex on skin thickness, skin collagen and density

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SUMMARY

Forearm skin collagen, dermal thickness and collagen density were measured in a large number of normal subjects as a standard reference for future studies. Skin collagen decreased with age and was less in the females at all ages. There is a direct relationship between skin collagen and dermal thickness but variations in collagen density in disease limit the use of dermal thickness as a guide to changes in its collagen content.

In the course of studies on the factors controlling skin collagen content in disease a large number of observations have been made on normal subjects. By measuring skin thickness at the same time we were also able to calculate collagen density (Black, Bottoms & Shuster, 1970; Shuster, Black & Bottoms, 1970; Black, Bottoms & Shuster, 1972 a, b & c, 1973). These measurements define certain of the factors controlling normal dermal thickness and collagen content and provide data which can serve as a reference point for future studies.

MATERIALS AND METHODS

Skin Collagen

Skin collagen was measured in seventy-four Caucasian males and eighty females aged 15–93 years. Most were attending the Department of Dermatology with a variety of minor localized skin disorders. A few of the skin samples were taken at post mortem. None of the patients was known to be suffering from endocrine or chronic wasting disease, nor had any been given corticosteroids.

The method was that of Shuster & Bottoms (1963). Biopsies were taken from the mid-point of the extensor aspect of the forearm using a high-speed 5 mm punch. In a few instances skin was taken in the same way at post mortem, since we have shown this to be without effect on total skin collagen content (unpublished observations). The biopsies and post mortem samples were defatted in acetone, dried to constant weight, hydrolysed and their hydroxyproline content measured by the method of Woessner (1961). The collagen content was then expressed as a function of the surface area of the biopsy since this is the most satisfactory way to measure skin collagen (Shuster & Bottoms, 1963; Shuster, Raffle & Bottoms, 1967 a, b).
Skin thickness
Skin thickness was measured in ninety Caucasian males and 107 females of age 12–93 years. The method was that of Meema, Sheppard & Rapoport (1964) as modified by Black (1969).

Collagen density
In twenty-seven males and twenty-six females both skin thickness and skin collagen were measured on adjacent areas of forearm skin and the collagen density was calculated from this.

RESULTS

1. Skin collagen
The relationship of skin collagen to age and sex is shown in Fig. 1(a and b). There is a linear decrease in skin collagen with age and the male forearm skin contains more collagen than the female at all ages studied.

![Graph showing the relationship of skin collagen content to age in males and females.](image)

FIGURE 1. The relationship of skin collagen content (expressed per unit skin surface area) to age in males (a) and females (b). Females have less collagen than males at all ages but the rate of decrease is the same in both sexes.

2. Skin thickness
The relationship of skin thickness to age and sex is shown in Fig. 2(a and b). For males at all ages studied a highly significant regression ($P<0.001$) was found showing gradual thinning of the skin with advancing age. By contrast in the female, skin thickness remained constant up until the 5th decade after which there was a significant decrease with age ($P<0.001$).

3. Relationship of skin collagen to thickness
There was a highly significant relationship ($P<0.001$) between thickness and the skin collagen content (Fig. 3a) for males at all ages studied. A similar and equally significant relationship ($P<0.001$) was found for females over 60 years of age but not in females under 60 years of age (Fig. 3b).
FIGURE 2. The relationship of skin thickness to age in males (a) and females (b). A relationship is apparent at all ages for males but only after middle age for the females.

FIGURE 3. The relationship of skin collagen and skin thickness in males (a) and females (b).

FIGURE 4. The relationship of skin collagen and density to age in males (a) and females (b).
4. Collagen density

Collagen density calculated as the ratio of skin collagen to thickness was very significantly \( P < 0.001 \) related to age in both males and females (Fig. 4a and b) but the density was consistently lower in females at all ages.

**DISCUSSION**

The present observations provide values for skin collagen content, density and skin thickness in relationship to age in normal men and women. So far as skin collagen is concerned the clear relationship to age is apparent, skin collagen decreasing linearly by about \( 1\% \) per year throughout adult life. Failure of previous investigations to find this decrease is due to the artefact of expressing skin collagen as a percentage, or in relationship to some other constituent of skin (Elden, 1970; Shuster & Bottoms 1963; Black et al., 1970a). This difficulty is avoided if parameters of skin structure and function are referred to surface area (Shuster & Bottoms, 1963; Shuster et al., 1967a, 1967b; Black et al., 1970a).

The rate of loss is the same in both males and females although total skin collagen content is less in females than males at all ages. One reason for this sex difference in skin collagen content may be androgen (Shuster et al., 1970; Black et al., 1970b; Burton et al., 1972). In adult skin the clinical features of ageing are closely related to the total collagen content (Shuster & Bottoms, 1963). The lower initial skin collagen content is therefore the reason women appear to age earlier than men. So far as their skin is concerned, age for age women are about 15 years older than men throughout their adult life. Although we have presented data from extensor skin of the forearm we have found precisely the same to be true of skin all over the body whether sun exposed or protected; moreover there is a direct correlation between the collagen content of skin taken from different parts of the body in all individuals studied; so that skin collagen content on the forearm can be taken as representative of all skin sites (Shuster & Bottoms, unpublished observations).

The finding of age and sex related changes in skin thickness was expected on clinical grounds (Shuster & Bottoms, 1963) and these changes are gross enough to be taken into account in studies of endocrine and other diseases (Stevenson, Bottoms & Shuster, 1970; Black et al., 1970a,b; Shuster et al., 1970; Black et al., 1972a, 1972b, 1972c, 1973; Meema et al., 1964). The constancy of skin thickness in adult women up to the 5th decade did surprise us and is not in agreement with the findings of Meema et al. (1964) who found a decrease at all ages. Although our modification (Black, 1969) of the method of Meema et al. (1964) reduces the effect of rotation of the arm and focus of the X-ray beam, the difference seems to be too great for such a methodological explanation. This part of our study would be worth repeating because the dissociation of skin thickness and collagen content up to the 5th decade in females implies either the structural maintenance of a looser dermal architecture or a greater density of ground substance between the collagen bundles as the primary event.

As with collagen and thickness, collagen density, the packing of fibrils in the dermis, is also influenced by age and sex. With increasing age, skin collagen decreases more rapidly than skin thickness so that collagen density decreases. That skin collagen is less densely packed in the female than in the male may be due to androgen since skin collagen density is increased in patients with primary cutaneous virilism (Shuster, 1972). Our findings also confirm that collagen is a major component of skin thickness; with the exception of the younger female skin, age related changes in thickness correlate well with skin collagen content. We have also shown this by a direct comparison of skin collagen measured chemically, and thickness measured histologically (Bottoms & Shuster, unpublished). Since however skin collagen density is also affected by other metabolic factors and by disease (Black et al., 1972b, 1972c, 1973, 1970) skin thickness cannot by itself be used as a measure of skin collagen content.
The measurement of skin thickness, collagen content and density has provided useful information in metabolic and endocrine diseases; it may also prove useful in monitoring the effect of drugs acting on connective tissue and in the investigation of diseases in which a generalized defect of connective tissue is suspected. Our present data in normal individuals are sufficient in number to use as a reference point for such future studies.

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REFERENCES

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