International Journal of Women's Dermatology 4 (2018) 122–130

Contents lists available at ScienceDirect

International Journal of Women's Dermatology

Male versus female skin: What dermatologists and cosmeticians should know

S. Rahrovan, MD, MPH [a], F. Fanian, MD, PhD [b], P. Mehryan, MD [a], P. Humbert, MD, PhD [b], A. Firooz, MD [a,*]

[a] Center for Research and Training in Skin Disease and Leprosy, Tehran University of Medical Sciences, Tehran, Iran
[b] Research and Studies Center on the Integument, Department of Dermatology, Clinical Investigation Center, Besançon University Hospital, University of Franche-Comté, Besançon, France

ARTICLE INFO

Article history:
Received 4 August 2017
Received in revised form 23 February 2018
Accepted 4 March 2018

ABSTRACT

Introduction: The skin is important for the perception of health and beauty. Knowledge of the physiological, chemical, and biophysical differences between the skin of male and female patients helps dermatologists develop a proper approach not only for the management of skin diseases but also to properly take care of cosmetic issues. The influence of genetic and environmental factors on skin characteristics is also critical to consider.

Methods: A literature search of PubMed and Google was conducted to compare the biophysical and biomechanical properties of the skin of male and female patients using the keywords "skin", "hydration", "water loss", "sebum", "circulation", "color", "thickness", "elasticity", "pH", "friction", "wrinkle", "sex", "male", and "female".

Results: A total of 1070 titles were found. After removing duplications and non-English papers, the number was reduced to 632. Of the 632 titles, 57 were deemed suitable for inclusion in this review. The studies show that the skin parameters of hydration, transepidermal water loss, sebum, microcirculation, pigmentation, and thickness are generally higher in men but skin pH is higher in women.

Conclusions: These parameters can be considered as age markers in some cases and are susceptible to change according to environment and life style. Biometrological studies of the skin provide useful information in the selection of active principles and other ingredients of formulations to develop a specific approach for cosmetic treatments.

Introduction

The skin is the largest multifunctional organ in the body. It functions as a protective physical barrier by absorbing ultraviolet radiation and preventing microorganism invasion and chemical penetration. The skin also controls the passage of water and electrolytes and has a major role in the thermoregulation of the body, in addition to its immunological, sensory, and autonomic function. Understanding the physiological, chemical, and biophysical characteristics of the skin helps us develop a proper approach for the management of skin diseases. However, the influence of genetic and environmental factors on the skin is also critical to consider.

Researchers have assessed skin parameters in different parts of the body in men and women separately. The knowledge of sex-linked cutaneous differences might help in study planning and the development of female- versus male-specific products for more appropriate dermatological treatments or cosmetic interventions.

There are sex-related differences in anatomy, physiology, epidemiology, and the manifestations of several diseases. With regard to skin disorders, infectious diseases are presented more in men but psychosomatic problems, pigmentary disorders, certain hair diseases, and autoimmune and allergic diseases are more common in women. Indeed, there are more sex-associated dermatoses in women and the occurrence and prognosis of certain skin malignancies are related to sex-related differences (Chen et al., 2010).

The mechanisms that underlie sex-related differences in skin diseases are mostly unknown. Sex hormones, behavioral factors, ethnicity, and differences in environment may all contribute to these differences. A better understanding of sex-related differences in human health and diseases will help better prevent, diagnose, and treat skin diseases (Chen et al., 2010).

A literature search of PubMed and Google was conducted through February 2017 using keywords including "skin", "hydration", "water loss", "sebum", "circulation", "color", "thickness", "elasticity", "pH",

* Corresponding Author.
E-mail address: firozali@sina.tums.ac.ir (A. Firooz).

https://doi.org/10.1016/j.ijwd.2018.03.002

"friction", "wrinkle", "sex", "male", and "female". Only articles of high quality that directly pertained to the biophysical and biomechanical properties of the skin in men and women were included.

A total of 1070 titles were found. After the removal of duplications and non-English papers, this number was reduced to 632 titles, of which 57 were deemed suitable for inclusion in this review by 2 of the authors (A.F. and P.H.).

Hydration

Stratum corneum (SC) hydration has an important role in skin function, such as the regulation of epidermal proliferation, differentiation, and inflammation. Table 1 provides the findings of studies that compared skin hydration between male and female skin.

Mac-Mary et al. (2006) showed that natural mineral water supplementation may be used to improve the hydration of skin dryness as a complementary cosmetic approach. Liu et al. (2012) found that sun-induced changes of SC hydration vary with age and sex in a normal Chinese population. Sun-exposure effect in SC hydration was not significant in young men and women but was significant in aged women. The reduction of SC hydration was significant on the forehead and dorsal hand of sun-exposed subjects. Sun-induced reduction of SC hydration was more obvious on the dorsal hand of aged women than that of men ($p < .001$). Furthermore, the SC rehydration capacity in sun-exposed aged female subjects was significantly lower than that of age-matched male subjects.

A German study conducted by Luebberding et al. (2013) demonstrated that young men showed higher levels of SC hydration in comparison with women. However, SC hydration was stable or even increased in women during their lifetime but decreased over time in men beginning at age 40 years. In a study by Man et al. (2009), SC hydration on the forehead in both men and women age >70 years was lower than that in younger age groups. SC hydration on the forehead in both men and women was not significantly different from that on the forearm. A comparison of age-matched men and women by Rogiers et al. (1990) demonstrated no sex-related differences in SC hydration.

Li et al. (2014) enrolled 86 patients in Chengdu, China in a single-center, non-interventional study. Candidates had two study visits (summer of 2010 and winter of 2011) at which dermatologists measured transepidermal water loss (TEWL), skin hydration, sebum secretion, fine lines/roughness, melanin/erythema, temperature, and color and clinically graded participants' skin. They found that the skin of female participants was significantly more hydrated than that of male participants.

Transepidermal water loss

TEWL is used to assess skin water barrier function. Jacobi et al. (2005) and Wilhelm et al. (1991) reported equal TEWL in both sexes in their studies. However, Luebberding et al. (2013) showed that in participants age <50 years, TEWL in men was significantly lower than in women of the same age, regardless of the location. The difference in evaporimetry results between men and women diminished with increased age at all localizations except for the forearm. In participants age 50 to 60 years, TEWL on the forehead, cheeks, and neck in men was higher than in women of the same age. In general and regardless of age, men showed significantly lower TEWL than women. In most sites, water loss was stable or increased over subjects' lifetime in both sexes.

Both Tupker et al. (1989) and Lammintausta et al. (1987) could not establish a difference in TEWL between men and women under basal conditions. Neither the number of tape strippings required for perturbing the barrier nor the rates of barrier recovery were significantly different in women compared with men (Reed et al., 1995). A summary of TEWL in male and female skin is presented in Table 2.

Sebum

Table 3 presents the findings of studies that compared skin sebum in male versus female skin. Jacobi et al. (2005) and Wilhelm et al. (1991) reported that sebum production was equal in the skin of men and women. However, Bailey et al. (2012) found higher sebum levels in male subjects in different parts of the face, except for the forehead, where female subjects had higher sebum levels.

Luebberding et al. (2013) demonstrated that sebum content in men was relatively stable on the cheeks and increased slightly on the forehead with age but progressively decreased in women over their lifetime. In a study by Man et al. (2009), sebum content on the forehead was higher in men ages 13 to 70 years than in age-matched women.

Men have been reported to have higher sebum production and larger pore size (Pochi and Strauss, 1974). A Korean study of 30 male and 30 female subjects found a striking positive correlation between male sex, pore size, and sebum excretion (Roh et al., 2006). In a study by Mizukoshi and Akamatsu (2013), sex-related differences and men's subjective perceptions of skin and daily skin care habits were investigated using simple instrumental measurements. The results showed that male skin had two specific characteristics because of the excess amount of sebum: impaired barrier function and a lack of appropriate skin care regimen due to tacky feeling. In a comparison of sebum secretion by sex, the skin of female participants was less oily on the face and neckline (Li et al., 2014).

Skin thickness

Shuster et al. (1975) studied a large number of normal subjects and measured forearm skin collagen, dermal thickness, and collagen density and concluded that the skin collagen decreased with age and was less in female subjects of all ages. They demonstrated that skin thickness in men decreased linearly with age, starting at age 20 years but remained constant in women until the age of approximately 50 years, at which time skin thickness started decreasing. The study concluded that skin thinning with age is the result of collagen loss. In fact, there is a positive correlation between levels of hydroxyl-proline (a major component of the protein collagen) and caliper-measured skin thickness.

According to Leveque et al. (1984), skin thickness starts to decrease at the age of 45 years in both men and women. The decrease of skin thickness and loss of hydroxyl proline have been suggested to be consequences of hormonal imbalances that are associated with menopause. In biopsies from women who were treated for 2 to 10 years with estradiol and testosterone, the hydroxyl-proline level was nearly 50% higher than that of age-matched untreated postmenopausal women (Brincat et al., 1983). The results of a study by Tur (1997) support this suggestion and showed that an ovariectomy is associated with the thinning of the skin but estrogen therapy thickens the skin.

Eisenbeiss et al. (1998) used 20 MHz sonography and showed that there is a positive correlation between the thickness of the skin and the level of sex hormones in fertile women. They suggested that this is the consequence of hormone-induced water retention in the skin. Ya-Xian et al. (1999) found great variations in the number of stratum corneum cell layers by location and among 301 individuals of various ages. Frozen 6-micron-thick sections were stained with a 1% aqueous solution of safranin and observed under a microscope after application of 2% potassium-hydroxide solution. There was no definite correlation between the number of corneocyte layers and

Table 1
Hydration in male versus female skin

Reference	Number	Age	Location	Measurement Device	Male	Female	P value
Firooz et al. (2012)	50	10-60 years	right side of forehead, cheek, nasolabial fold, neck, forearm, dorsal side of the hand, palm and leg	Corneometer (Courage & Khazaka electronic GmbH, Cologne, Germany)	48.42 AU	49.06 AU	non-significant
Jacobi et al. (2005)	6 women	24.3 ± 0.8 years	flexor forearm	Corneometer CM 820 (Courage & Khazaka, Cologne, Germany)	75.3 ± 12.8 AU	72.7 ± 8.1 AU	non-significant ($p>0.05$)
	6 men	24.2 ± 0.4 years					
Wilhelm et al. (1991)	7 male 7 female 7 male 8 female	26.7 ± 2.8 years 70.5 ± 13.8 years	forehead, dorsal aspect of the upper arm, dorsal and volar aspects of the forearm, postauricular region, palm, abdomen, upper and lower part of the back, extensor surface of the thigh, and ankle (approximately 4 cm distal to the medial malleolus)	capacitance meter (Corneo meter CM 820 PC, Courage & Khazaka, Cologne, Federal Republic of Germany)	not available	not available	no significant differences
Mac-Mary et al. (2006)	80	56 ± 5.6 years	randomized forearm	Evaporimeter EP1 (Servomed, Stockholm, Sweden)	33.33 (6.00) AU (baseline)	34.50 (4.96) AU (baseline)	
					to 40.19 (7.73) AU (after 21 days of natural mineral water supplementation)	to 37.41(6.97) AU	significant ($p=0.001$ for male & $p<0.005$ for female)
					to 40.28 (8.25) AU (after 42 days of natural mineral water supplementation)	to 38.91(7.27) AU	significant ($p=0.001$ for male & $p<0.001$ for female)
Liu et al. (2012)	168	19–75 years	forehead and the dorsal hand	multifunctional skin physiology monitor	not available	not available	significantly Lower on dorsal hand of sun-exposed subjects in aged females ($p<0.001$)
Bailey et al. (2012)	88	18-61 years	facial and abdominal skin	Corneometer CM825 attached to Derma Unit SSC3 (CK Electronic, Koln, Germany)	Jowl (50.01) AU Neck (49.66) AU Abdomen (33.05) AU	Jowl (54.60) AU Neck (59.58) AU Abdo-men(38.96) AU	significant($p<0.005$)
Luebberding et al. (2013)	300	20-74 years	forehead, cheek, neck, volar forearm and dorsum of hand	Corneometer® CM 825 (Courage & Khazaka, Cologne, Germany)	48.76 ± 7.15 (CM Units)	50.29 ± 5.88 (CM Units)	not available
Man et al. (2009)	713	0.5-94 years	forehead and forearm (flexor site)	Corneometer CM 825 attached to a Courage & Khazaka MPA5 system	43.99 ± 1.88 AU (13–35 years)	36.38 ± 1.67 AU (13–35 years)	significant ($p<0.01$)
Li et al. (2014)	43 men and women and their 43 consanguineous same-sex children	40–50 years 18–25 years	face, décolletage, back of hand, outer forearm, lower outer leg, and heel	capacitance-based Corneometer ® CM 825, by Courage & Khazaka	not available	not available	Female skin was significantly more hydrated [décolletage in winter, hand in summer and winter), except for the heel that was dryer.

AU, arbitrary unit, CM, arbitrary unit

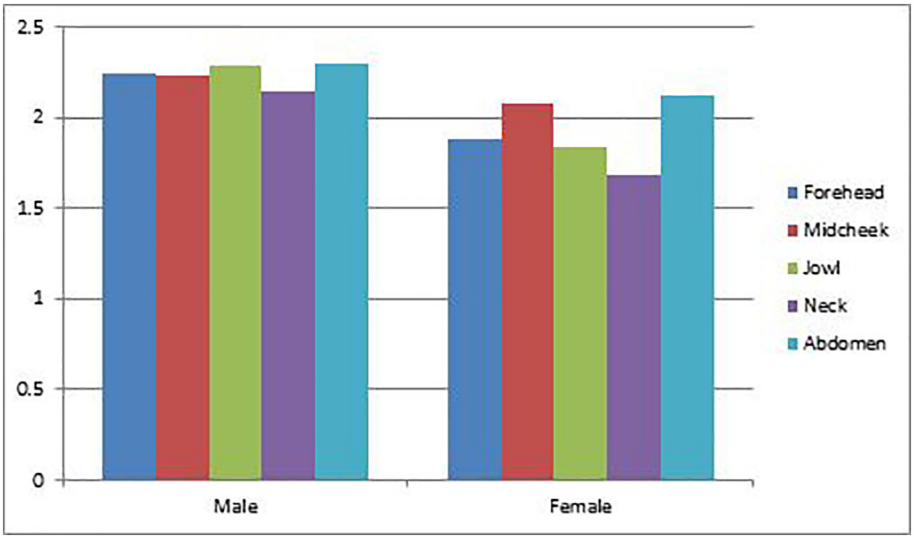

Fig. 1. Skin thickness (μm; Bailey et al., 2012)

sex of the individual, but there was a slight increase in the number of SC layers with age in the skin on the cheek and back, especially in male individuals.

Mogensen et al. (2008) found no sex or skin type-related differences in epidermal thickness using optical coherence tomography imaging, which is based on infrared light reflection/backscatter from tissue. Gambichler et al. (2006) studied 83 subjects using optical coherence tomography imaging in vivo and performing intra- and interday repeatability measurements. The results showed that epidermal thickness did not significantly differ between men and women except for the forehead skin, which was significantly thinner in older women than in men. The comparison of skin thickness between male and female skin is presented in Table 4.

Skin pH

Bailey et al. (2012) reported that skin pH is lower (ie, more acidic) in men, but a study by Zlotogorski (1987) showed that skin pH was not correlated with sex. In the study by Luebberding et al. (2013), skin pH was highest in the cheeks in both sexes. The female forehead and male hand had the lowest pH. Except for a few areas, especially the forehead, the pH value of female subjects was always >5. With regard to age, an increasing trend in pH value was only seen in men.

Sex and sex hormones are generally accepted to not exert (or have only minor) effects on skin surface pH (Burry et al., 2001; Fluhr et al., 2004; Yosipovitch et al., 1993). Single studies have reported slight sex variances in pH that is attributed to different cosmetic

Table 2
Transepidermal water loss in male versus female skin

Reference	Number	Age	Location	Measurement Device	Male	Female	P value
Firooz et al. (2012)	50	10-60 years	right side of forehead, cheek, nasolabial fold, neck, forearm, dorsal side of the hand, palm and leg	TEWAmeter (Courage & Khazaka electronic GmbH, Cologne, Germany)	15.49 gr/h.m^2	9.52 gr/h.m^2	Significant
Luebberding et al. (2013)	300	20-74 years	Hand forearm	Tewameter® TM 300; Courage & Khazaka	10.92 ± 3.36 gr/h.m^2 5.50 ± 2.02 gr/h.m^2	11.52 ± 3.61 gr/h.m^2 9.10 ± 2.25 gr/h.m^2	significant ($p<0.05$)
Chilcott and Farrar (2000)	17	18-28 years	volar forearm	ServoMed EP-2 Evaporimeter (ServoMed, Kinna, Sweden)	4.94 ± 0.31 g/m^2/h	4.68 ± 0.27 g/m^2/h	$p<0.05$
Giusti et al. (2001)	70	8 to 24 months	volar forearm buttock	Evaporimeter (EPI; Servomed, Stockholm, Sweden)	8.57 ± 2.52 g/m^{2}h 9.12 ± 2.77 g/m^{2}h	8.17 ± 2.20 g/m^{2}h 9.04 ± 2.43 g/m^{2}h	No statistically significant differences
Fluhr et al. (2001)	21 postmenopausal women, 33 premenopausal women, 25 men	mean age 50.6 years mean age 41.0 years mean age 44.0 years	not available	noninvasive exfoliation method, videomicroscopy and image analyses (NIH Image 1.59)	not available	not available	No statistically significant differences
Li et al. (2014)	43 men and women and their 43 consanguineous same-sex children	40–50 years 18–25 years	face, décolletage, back of hand, outer forearm, lower outer leg, and heel	Tewameter® (TM 210; Courage & Khazaka, Koln, Germany)	not available	not available	Significantly lower in females

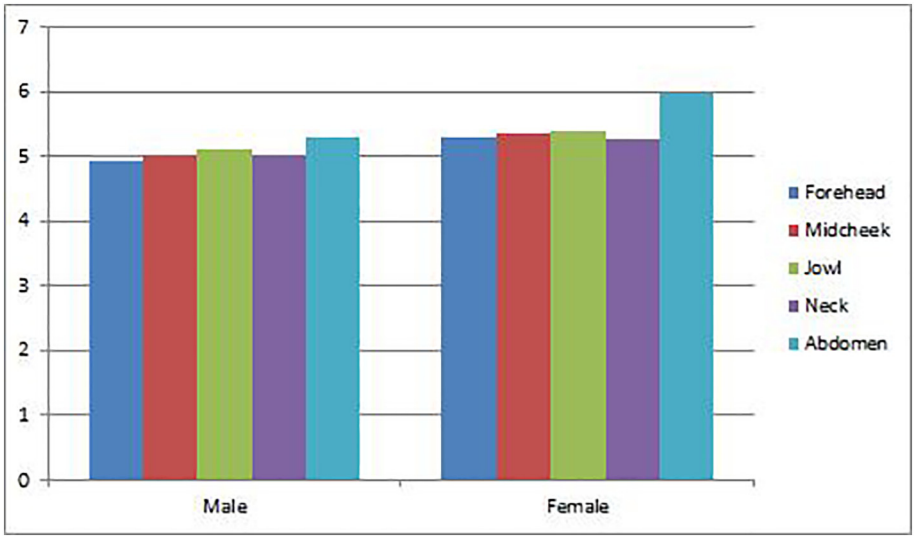

Fig. 2. Skin pH (Bailey et al., 2012)

habits (Parra and Paye, 2003). During the postnatal period, a rapid decrease in pH was observed during the first week, and a gradual decrease during the next 3 weeks was measured. In contrast, other studies could not confirm sex-related differences in infants (Harpin and Rutter, 1983; Hoeger and Enzmann, 2002). The results of a study by Wilhelm et al. (1991) demonstrated no difference in pH values between men and women on most anatomic regions. Studies that compare skin pH in male versus female skin are presented in Table 5.

Microcirculation

Hornstra et al. (2014) studied 260 participants (mean age: 42 years; 47% men) and demonstrated that there was a negative, nonlinear relationship between homocysteine and baseline capillary density in men. The study also showed a lower capillary density in the highest tertial of homocysteine (adjusted B: −8.65 capillaries/mm2 [95% confidence interval, −16.05 to −1.25]; $p = .02$), but no significant association was found between homocysteine and microvascular outcomes in women. In addition, higher homocysteine levels were associated with a reduction in basal perfusion of skin capillaries in men.

Rodrigues et al. (2001) studied the hemodynamically vascular response to a local reactive hyperemia procedure (ie, tourniquet cuff maneuver) in two previously selected groups of volunteers (eight women and eight men). They assessed the effect of sex under standardized experimental conditions using the transcutaneous flow-related variables tcpO2-tcpCO2 and laser-doppler flowmetry. In these experimental conditions, no sex-related influence was found.

Skin color

Fullerton and Serup (1997) studied baseline color in the upper, middle, and lower levels of the upper back and on the forearms of 168 European volunteers with the Minolta ChromaMeter. These

Table 3
Sebum in male versus female skin

Reference	Number	Age	Location	Measurement Device	Male	Female	P value
Firooz et al. (2012)	50	10-60 years	right side of forehead, cheek, nasolabial fold, neck, forearm, dorsal side of the hand, palm and leg	Sebumeter, (Courage & Khazaka electronic GmbH, Cologne, Germany).	60.39μg/cm^2	42.19μg/cm^2	non-significant
Luebberding et al. (2013)	300	20-74 years	cheek forehead	Sebumeter® SM 815; Courage & Khazaka	84.17 ± 51.15 μg cm^{-2} 127.75 ± 56.10 μg cm^{-2}	48.66 ± 40.53 μg cm^{-2} 105.45 ± 61.66 μg cm^{-2}	significant at the cheek for all age groups, and at the forehead for age groups IV and V ($p<0.05$)
Man et al. (2009)	713	0.5–94 years	forearm, forehead (flexor site)	Sebum Cassette attached to a Courage & Khazaka MPA5 system	36-50 years: 93.47 ± 10.01 μg/cm^2 51-70 years: 9.16 ± 1.95 μg/cm^2	13-35 years: 61.91 ± 6.12 μg/cm^2 51-70 years: 7.54 ± 2.55 μg/cm^2	Significant
Jacobi et al. (2005)	6 men 6 women	24.2 ± 0.4 years 24.3 ± 0.8 years	flexor forearm	sebumeter SM 810 (Courage & Khazaka, Cologne, Germany)	3.0 ± 4.6 μg/cm^2	0.7 ± 0.5 μg/cm^2	non-significant ($p>0.05$)
Kim et al. (2006)	46 women 37 men	21-37 y 23-29 y	five facial sites: nose tip, chin, forehead, right cheek, left cheek	Sebumeter SM 815® (Courage & Khazaka, Koln or Cologne, Germany)	not available	not available	significantly higher in males

Table 4
Skin thickness in male versus female skin

Reference	Number	Age	Location	Measurement Device	Male	Female	P value
Bailey et al. (2012)	88	18-61 years	forehead, midcheek, jowl, neck, and infraumbilical region	DermaScan C 20 MHz (Cyberderm, Broomall, PA)	men had an overall 10-20% thicker than women (Figure 1)		p<0.003
Sandby-Moller et al. (2003)	71	20-68 years	forearm dorsal shoulder buttock	calibrated square grid after biopsy	not available	not available	significantly higher in men (p<0.0001) (Thickness of the cellular epidermis)
Mayrovitz et al. (2012)	30 men	25.6±2.9 years	Forehead	MoistureMeter- D (Delfin Technologies Ltd, Kuopio, Finland)	39.6 ± 2.7 TDC unit	37.4 ± 3.3 TDC unit	p=0.001
	30 women	26.3±4.4 years	cheek		35.9 ± 4.9 TDC unit	32.8 ± 3.8 TDC unit	p=0.009
			forearm		31.5 ± 3.2 TDC unit	28.3 ± 2.4 TDC unit	p<0.001
Mayrovitz et al. (2010)	30 men 30 women	25.0 +/- 2.5 y 27.4 +/- 6.6 y	volar forearm	Tissue dielectric constant (TDC) measurements at 300 MHz via the coaxial line reflection method using a probe with an effective measurement depth of 1.5 mm.	33.2 +/- 4.0 TDC unit	29.4 +/- 2.7 TDC unit	p<0.001
Firooz et al. (2017)	30	24-61 y	cheek, neck, palm, sole, dorsum of foot	high frequency ultrasonography using 22 and 50 MHz probes	neck: 1592.17 (452.30) μm dorsum of foot: 1666.54 μm (430.03)	neck: 1253.47 μm (252.51) dorsum of foot: 1258.12 μm (391.37)	significant in neck and dorsum of foot (p<0.05)

TDC, tissue dielectric constant

two sites are usually used in skin testing. Female participants showed a generally lower basal a* level than male participants, both on the upper back and forearm skin (a* value is the chromacity coordinates and represents the balance between green [negative values] and red [positive values]). Therefore, when planning irritancy studies where color differences between erythema and normal skin are used, such important differences between the sexes must be considered.

In another comparative Asian study of skin color by sex, the skin of female participants was lighter on exposed sites and more yellow on hands during the winter (Li et al., 2014). In an Asian study by Firooz et al. (2012), skin melanin index was significantly higher in male subjects (male: 214.82; female: 176.82). Roh et al. (2001) studied sex-related variations in the skin pigmentation of 497 Korean subjects (age range: 0-87 years) during the winter and 311 subjects (age range: 0-84 years) during the summer (110 subjects were assessed during both seasons). They analyzed five different body sites (buttock, glabella, V-neck area, inner arm, and dorsal forearm). The results showed significant differences in all body regions after the first decade. Also, women had significantly lighter constitutive pigmentation than men except during the first decade.

Many artists in various cultures of the world have made their female models lighter skinned than male models. There is a biologic truth behind this. Several spectrophotometric studies have shown that in diverse populations in Europe, Asia, Africa, and North and South America, female skin reflectance is 2 to 3 percentage points above that of male skin (having a higher reflectance means having paler skin.); (Tegner, 1992). In an Asian comparison of melanin/erythema by sex, the skin of female participants was less erythematous on exposed sites (Li et al., 2014).

Skin elasticity

Firooz et al. (2012) reported that skin elasticity was higher in female subjects than in male subjects; however, the difference was not statistically significant (male: 0.27; female: 0.273). Ishikawa et al. (1995) and Ezure et al. (2011) reported that skin elastic properties

Table 5
pH in male versus female skin

Reference	Number	Age	Location	Measurement Device	Male	Female	P value
Bailey et al. (2012)	88	18-61 years	forehead, midcheek, jowl, neck, abdomen	pH meter PH905 attached to Derma Unit SSC3 (CK Electronic, Koln, Germany)	Figure 2		Significant
Luebberding et al. (2013)	300	20-74 years	forehead, cheek, neck, volar forearm and dorsum of hand	Skin-pH-Meter® PH 905 (Courage & Khazaka)	not available	not available	significantly lower in male (p<0.05)
Giusti et al. (2001)	70	8 to 24 months	volar forearm buttock	pH meter (pH 90, Schwarzhaupt, Medizintechnik, Germany)	5.46±0.61 5.97±0.65	5.45±0.68 5.93±0.64	not available
Fox et al. (1998)	40	very low birth weight Infants over the first month of life	not available	a glass flat-surface pH electrode	6.40	6.10	significant
Ehlers et al. (2001)	6 men 5 women	31–59 years 26–54 years	flexor surface of the forearm	a skin pH meter (pH meter 1140; Mettler Toledo, Greisensee, Switzerland)	5.80	5.54	significant (p<0.01)
Kim et al. (2006)	46 women 37 men	21-37 years 23-29 years	five facial sites, T-Zone, U-zone	Skin-pH-Meter PH 905® (Courage & Khazaka, Koln, Germany)	not available	not available	significantly lower in males in T-zone, U-zone, and mean facial pH (p<0.001)

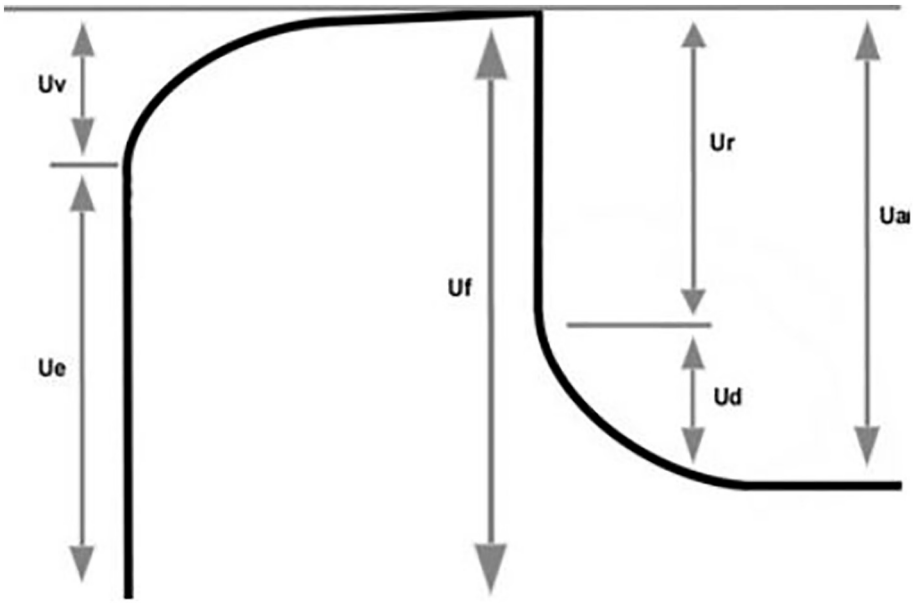

Fig. 3. Skin deformation in relation to time (μm; Luebberding et al., 2014)

were not correlated with sex. Bailey et al. (2012) reported that elastic deformation was higher in female subjects but only in the skin on the abdomen. Skin stiffness was also higher in female participants, but the difference was only significant in the skin on the abdomen.

Luebberding et al. (2014) selected 300 healthy male and female subjects (age range: 20-74 years) on the basis of age, sun behavior, or smoking habits. Skin mechanical properties were assessed on the cheeks, neck, volar forearm, and dorsum of the hand using a noninvasive suction device. Five parameters were used to assess skin mechanical properties: gross elasticity (Ua/Uf), net elasticity (Ur/Ue), ratio of elastic recovery to distensibility (Ur/Uf; all in percent). Absolute parameters, immediate recovery (Ur), maximum recovery (Ua), skin distensibility, and immediate distensibility (all in μm) were analyzed. They showed that at a young age, the results of the relative parameters are higher for women but the absolute parameters are higher for men. The relative parameters (Ua/Uf, Ur/Ue, and Ur/Uf) are calculated from the ratio between two distances and are expressed as a percent. The absolute parameters (Ua, Ur, Uf, and Ue) are single-distance parameters such as stretching or recovery phase and are expressed as micrometers (Fig. 3). The researchers also concluded that the mechanical properties changed differently in men and woman over their lifetime and that female skin is less distensible but has a higher ability to recover after stretching in comparison with male skin.

Xin et al. (2010) showed that with aging, cutaneous resonance running time (CRRT) decreased in all directions on the hand, forehead, and canthus. (The measurement of CRRT is a noninvasive approach to assess skin biophysical property that is mainly influenced by collagen fibers in the papillary layers of the dermis and correlates negatively with skin stiffness (Ruvolo et al., 2007; Vexler et al., 1999)). There was a more dramatic reduction in CRRT on the forehead and canthus in both the 2 to 8 and 3 to 9 o'clock directions. In males ages 11 to 20 years, CRRTs were longer than those in females in some directions at all three body sites. CRRTs were longer in women ages 21 to 40 years than in men in some directions of the hand. No sex-related differences were seen in subjects ages 0 to 10 years (except on the canthus) and those age >80 years.

Skin friction

Zhu et al. (2011) showed that the maximum skin friction coefficients on the canthus and dorsal hand skin were seen around age 40 years in women, but the skin friction coefficient on the dorsal hand gradually increased from ages 0 to 40 years and then changed little in men. There was a significant positive correlation between skin friction coefficient and stratum corneum hydration on the canthus and dorsal hand skin for women and on the forehead and dorsal hand skin for men. In a comparison of roughness by sex, the skin of female participants was scalier (Li et al., 2014).

Human face geometry

Ezure et al. (2011) photographed the faces of 98 healthy Japanese male volunteers in their 20s to 60s at an angle of 45 degrees. They also used photographs of 108 healthy Japanese female volunteers in their 20s to 60s to compare the difference in morphological characteristics of sagging between men and women. They evaluated the sagging severity of the upper and lower cheeks by using photograph-based grading criteria and showed that sagging severity in the upper and lower cheeks was almost equal between men and women of all ages, but after middle age, the sagging of the lower eyelid in men was significantly more severe than that of women. Facial sagging in both men and women had a significantly negative relation with dermal elasticity parameters.

Inoue (1990) showed a significant sex-related difference in the forehead of the skull. For example, the supraorbital ridge was more developed in men than in women and the forehead shape was receding instead of rounded and had a more even surface in women.

Wrinkles

Tsukahara et al. (2013) reported that in all age groups of 173 Japanese men and women, men showed increased forehead wrinkles

compared with women. No sex-dependent differences were found in upper eyelid wrinkles. With the exception of the oldest age group (age: 65-75 years) in which wrinkles in women were greater than or equal to those of men, other facial wrinkles were greater in men in all groups.

Akiba et al. (1999) investigated sex-related differences in sun exposure in subjects <60 years old and suggested that lower levels of sun exposure in women may result in fewer wrinkles. In a comparison study of fine lines by sex, the skin of female participants was shown to be smoother (Li et al., 2014).

Conclusions

Several studies have compared the biophysical properties of the skin between men and women. For some parameters, the same results were generally reported. For example, sebum content is higher in men because sebum is highly influenced by sex hormones. Also, skin pigmentation and thickness are significantly higher, facial wrinkles are deeper, and facial sagging is more prominent in the lower eyelids of men, but there is no significant difference in skin elasticity between the sexes.

On the other hand, the results on other parameters are conflicting, which might be due to differences in study design, measurement devices, sample size, measuring site, environmental conditions, and the genetic backgrounds of the subjects. These differences should be taken into account when designing clinical studies and when prescribing topical products to treat patients.

References

Akiba S, Shinkura R, Miyamoto K, Hillebrand G, Yamaguchi N, Ichihashi M. Influence of chronic UV exposure and lifestyle on facial skin photo-aging–results from a pilot study. J Epidemiol 1999;9:S136–42.

Bailey SH, Oni G, Brown SA, Kashefi N, Cheriyan S, Maxted M, et al. The use of non-invasive instruments in characterizing human facial and abdominal skin. Lasers Surg Med 2012;44:131–42.

Brincat M, Moniz CF, Studd JW, Darby AJ, Magos A, Cooper D. Sex hormones and skin collagen content in postmenopausal women. Br Med J (Clin Res Ed) 1983;287:1337–8.

Burry JS, Coulson HF, Esser I, Marti V, Melling SJ, Rawlings AV, et al. Erroneous gender differences in axillary skin surface/sweat pH. Int J Cosmet Sci 2001;23:99–107.

Chen W, Mempel M, Traidl-Hofmann C, Al Khusaei S, Ring J. Gender aspects in skin diseases. J Eur Acad Dermatol Venereol 2010;24:1378–85.

Chilcott RP, Farrar R. Biophysical measurements of human forearm skin in vivo: Effects of site, gender, chirality and time. Skin Res Technol 2000;6:64–9.

Ehlers C, Ivens UI, Moller ML, Senderovitz T, Serup J. Females have lower skin surface pH than men. A study on the surface of gender, forearm site variation, right/left difference and time of the day on the skin surface pH. Skin Res Technol 2001;7:90–4.

Eisenbeiss C, Welzel J, Schmeller W. The influence of female sex hormones on skin thickness: Evaluation using 20 MHz sonography. Br J Dermatol 1998;139:462–7.

Ezure T, Yagi E, Kunizawa N, Hirao T, Amano S. Comparison of sagging at the cheek and lower eyelid between male and female faces. Skin Res Technol 2011;17:510–5.

Firooz A, Sadr B, Babakoohi S, Sarraf-Yazdy M, Fanian F, Kazerouni-Timsar A, et al. Variation of biophysical parameters of the skin with age, gender, and body region. Sci World J 2012;2012:386936.

Firooz A, Rajabi-Estarabadi A, Zartab H, Pazhohi N, Fanian F, Janani L. The influence of gender and age on the thickness and echo-density of skin. Skin Res Technol 2017;23:13–20.

Fluhr JW, Pelosi A, Lazzerini S, Dikstein S, Berardesca E. Differences in corneocyte surface area in pre- and post-menopausal women. Assessment with the noninvasive videomicroscopic imaging of corneocytes method (VIC) under basal conditions. Skin Pharmacol Appl Ski Physiol 2001;14:6–10.

Fluhr JW, Mao-Qiang M, Brown BE, Hachem JP, Moskowitz DG, Demerjian M, et al. Functional consequences of a neutral pH in neonatal rat stratum corneum. J Invest Dermatol 2004;123:140–51.

Fox C, Nelson D, Wareham J. The timing of skin acidification in very low birth weight infants. J Perinatol 1998;18:272–5.

Fullerton A, Serup J. Site, gender and age variation in normal skin colour on the back and the forearm: Tristimulus colorimeter measurements. Skin Res Technol 1997;3:49–52.

Gambichler T, Matip R, Moussa G, Altmeyer P, Hoffmann K. In vivo data of epidermal thickness evaluated by optical coherence tomography: Effects of age, gender, skin type, and anatomic site. J Dermatol Sci 2006;44:145–52.

Giusti F, Martella A, Bertoni L, Seidenari S. Skin barrier, hydration, and pH of the skin of infants under 2 years of age. Pediatr Dermatol 2001;18:93–6.

Harpin VA, Rutter N. Barrier properties of the newborn infant's skin. J Pediatr 1983;102:419–25.

Hoeger PH, Enzmann CC. Skin physiology of the neonate and young infant: A prospective study of functional skin parameters during early infancy. Pediatr Dermatol 2002;19:256–62.

Hornstra JM, Hoekstra T, Serne EH, Eringa EC, Wijnstok NJ, Blom HJ, et al. Homocysteine levels are inversely associated with capillary density in men, not in premenopausal women. Eur J Clin Invest 2014;44:333–40.

Inoue M. Fourier analysis of the forehead shape of skull and sex determination by use of computer. Forensic Sci Int 1990;47:101–12.

Ishikawa T, Ishikawa O, Miyachi Y. Measurement of skin elastic properties with a new suction device (I): Relationship to age, sex and the degree of obesity in normal individuals. J Dermatol 1995;22:713–7.

Jacobi U, Gautier J, Sterry W, Lademann J. Gender-related differences in the physiology of the stratum corneum. Dermatology 2005;211:312–7.

Kim MK, Patel RA, Shinn AH, Choi SY, Byun HJ, Huh CH, et al. Evaluation of gender difference in skin type and pH. J Dermatol Sci 2006;41:153–6.

Lammintausta K, Maibach HI, Wilson D. Irritant reactivity in males and females. Contact Dermatitis 1987;17:276–80.

Leveque JL, Corcuff P, de Rigal J, Agache P. In vivo studies of the evolution of physical properties of the human skin with age. Int J Dermatol 1984;23:322–9.

Li X, Galzote C, Yan X, Li L, Wang X. Characterization of Chinese body skin through in vivo instrument assessments, visual evaluations, and questionnaire: Influences of body area, inter-generation, season, sex, and skin care habits. Skin Res Technol 2014;20:14–22.

Liu Z, Song S, Luo W, Elias PM, Man MQ. Sun-induced changes of stratum corneum hydration vary with age and gender in a normal Chinese population. Skin Res Technol 2012;18:22–8.

Luebberding S, Krueger N, Kerscher M. Skin physiology in men and women: in vivo evaluation of 300 people including TEWL, SC hydration, sebum content and skin surface pH. Int J Cosmet Sci 2013;35:477–83.

Luebberding S, Krueger N, Kerscher M. Mechanical properties of human skin in vivo: A comparative evaluation in 300 men and women. Skin Res Technol 2014;20:127–35.

Mac-Mary S, Creidi P, Marsaut D, Courderot-Masuyer C, Cochet V, Gharbi T, et al. Assessment of effects of an additional dietary natural mineral water uptake on skin hydration in healthy subjects by dynamic barrier function measurements and clinic scoring. Skin Res Technol 2006;12:199–205.

Man MQ, Xin SJ, Song SP, Cho SY, Zhang XJ, Tu CX, et al. Variation of skin surface pH, sebum content and stratum corneum hydration with age and gender in a large Chinese population. Skin Pharmacol Physiol 2009;22:190–9.

Mayrovitz HN, Carson S, Luis M. Male-female differences in forearm skin tissue dielectric constant. Clin Physiol Funct Imaging 2010;30:328–32.

Mayrovitz HN, Bernal M, Carson S. Gender differences in facial skin dielectric constant measured at 300 MHz. Skin Res Technol 2012;18:504–10.

Mizukoshi K, Akamatsu H. The investigation of the skin characteristics of males focusing on gender differences, skin perception, and skin care habits. Skin Res Technol 2013;19:91–9.

Mogensen M, Morsy HA, Thrane L, Jemec GB. Morphology and epidermal thickness of normal skin imaged by optical coherence tomography. Dermatology 2008;217:14–20.

Parra JL, Paye M. EEMCO guidance for the in vivo assessment of skin surface pH. Skin Pharmacol Appl Ski Physiol 2003;16:188–202.

Pochi PE, Strauss JS. Endocrinologic control of the development and activity of the human sebaceous gland. J Invest Dermatol 1974;62:191–201.

Reed JT, Ghadially R, Elias PM. Skin type, but neither race nor gender, influence epidermal permeability barrier function. Arch Dermatol 1995;131:1134–8.

Rodrigues LM, Pinto PC, Leal A. Transcutaneous flow related variables measured in vivo: The effects of gender. BMC Dermatol 2001;1:4.

Rogiers V, Derde M, Verleye G, Roseeuw D. Standardized conditions needed for skin surface hydration measurements. Cosmet Toiletries 1990;105:73–82.

Roh K, Kim D, Ha S, Ro Y, Kim J, Lee H. Pigmentation in Koreans: Study of the differences from Caucasians in age, gender and seasonal variations. Br J Dermatol 2001;144:94–9.

Roh M, Han M, Kim D, Chung K. Sebum output as a factor contributing to the size of facial pores. Br J Dermatol 2006;155:890–4.

Ruvolo Jr EC, Stamatas GN, Kollias N. Skin viscoelasticity displays site- and age-dependent angular anisotropy. Skin Pharmacol Physiol 2007;20:313–21.

Sandby-Moller J, Poulsen T, Wulf HC. Epidermal thickness at different body sites: Relationship to age, gender, pigmentation, blood content, skin type and smoking habits. Acta Derm Venereol 2003;83:410–3.

Shuster S, Black MM, McVitie E. The influence of age and sex on skin thickness, skin collagen and density. Br J Dermatol 1975;93:639–43.

Tegner E. Sex differences in skin pigmentation illustrated in art. Am J Dermatopathol 1992;14:283–7.

Tsukahara K, Hotta M, Osanai O, Kawada H, Kitahara T, Takema Y. Gender-dependent differences in degree of facial wrinkles. Skin Res Technol 2013;19:e65–71.

Tupker RA, Coenraads PJ, Pinnagoda J, Nater JP. Baseline transepidermal water loss (TEWL) as a prediction of susceptibility to sodium lauryl sulphate. Contact Dermatitis 1989;20:265–9.

Tur E. Physiology of the skin–differences between women and men. Clin Dermatol 1997;15:5–16.
Vexler A, Polyansky I, Gorodetsky R. Evaluation of skin viscoelasticity and anisotropy by measurement of speed of shear wave propagation with viscoelasticity skin analyzer. J Invest Dermatol 1999;113:732–9.
Wilhelm KP, Cua AB, Maibach HI. Skin aging. Effect on transepidermal water loss, stratum corneum hydration, skin surface pH, and casual sebum content. Arch Dermatol 1991;127:1806–9.
Xin S, Man W, Fluhr JW, Song S, Elias PM, Man MQ. Cutaneous resonance running time varies with age, body site and gender in a normal Chinese population. Skin Res Technol 2010;16:413–21.
Ya-Xian Z, Suetake T, Tagami H. Number of cell layers of the stratum corneum in normal skin - relationship to the anatomical location on the body, age, sex and physical parameters. Arch Dermatol Res 1999;291:555–9.
Yosipovitch G, Tur E, Cohen O, Rusecki Y. Skin surface pH in intertriginous areas in NIDDM patients. Possible correlation to candidal intertrigo. Diabetes Care 1993;16:560–3.
Zhu YH, Song SP, Luo W, Elias PM, Man MQ. Characterization of skin friction coefficient, and relationship to stratum corneum hydration in a normal Chinese population. Skin Pharmacol Physiol 2011;24:81–6.
Zlotogorski A. Distribution of skin surface pH on the forehead and cheek of adults. Arch Dermatol Res 1987;279:398–401.