STUDY

Cutaneous Photodamage in Koreans

Influence of Sex, Sun Exposure, Smoking, and Skin Color

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Background: Severe wrinkles and pigmentary changes of the exposed skin indicate substantial damage due to UV radiation. Many investigators believe that the principal manifestation of photodamage in Asians is pigmentary change rather than wrinkles. However, to our knowledge, no well-designed study has investigated the characteristics of cutaneous photodamage in Asian skin.

Objective: To access the severity of wrinkles and dyspigmentation in Koreans exposed to sun and who smoked.

Methods: We developed new photographic scales for grading wrinkles and dyspigmentation in 407 Koreans to assess the severity of the wrinkles and dyspigmentation. We interviewed subjects to determine cumulative sun exposure and smoking history, and measured the skin color of individual subjects.

Results: Our photographic scales provided a reliable evaluation of photodamage severity in Koreans. The pattern of wrinkling in both sexes is similar, but women tended to have more severe wrinkles (prevalence odds ratio, 3.7). However, the pattern of dyspigmentation differed between the sexes. Seborrheic keratosis is the major pigmentary lesion in men, whereas hyperpigmented macules are the prominent features in women. Cigarette smoking is an independent risk factor for wrinkles, but not for dyspigmentation, in Koreans, and causes additive detrimental effects to wrinkles induced by aging and sun exposure. The constitutive skin color did not show any correlation with wrinkles or dyspigmentation. However, facultative pigmentation (sun exposure index) may reflect lifetime sun exposure, and it shows a good correlation with wrinkles in Koreans.

Conclusion: Wrinkling is a major feature of photoaging in Koreans, as are pigmentary changes; smoking, sun exposure, and female sex are independent risk factors for wrinkles.

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THE PRESENCE of wrinkles and pigmentary changes, such as solar lentigo, as well as mottled pigmentation on the face or other exposed areas, usually indicate substantial damage due to exposure to sunlight.[1] Many investigators believe, based on their experiences, that the principal manifestation of photodamage in Asians is pigmentary change rather than wrinkling.[2-4] However, to our knowledge, no well-designed study has investigated the characteristics of cutaneous photodamage in Asian skin. The people of Asia consist of mostly Mongoloids and some Caucasians. Mongoloids usually include people of East Asia, Indonesia, and Polynesia; Native Americans; Eskimos, etc. Their skin color is usually brown. The people of Central Asia and India are Caucasian, but they have brown skin color, in contrast to most Caucasians with white skin. The people of Korean descent are typical Mongoloids and have brown skin.[5]

Griffiths et al[3] and Larnier et al[4] have developed photographic scales for the assessment of photodamage in white subjects, which have proved to be superior to descriptive written scales. In general, evaluation of the characteristic features of photoaging (eg, fine and coarse wrinkling, pigmentary lesions, and coarseness) into a single score expressing overall severity is difficult. It is quite common for one individual to have extensive wrinkling with little pigmentary change, whereas another may have mild wrinkling but severe dyspigmentation. Thus, to assess the severity of photoaging in the brown skin of Asians, we have developed the following 2 separate scales: an 8-point photographic scale for assessing wrinkles and a 6-point photographic scale for grading dyspigmentation in male and female Korean subjects. In this study, we investigated the correlation of wrinkling with pigmentary changes, their relative importance in photoaging in Koreans, and their differences according to sex.

Several studies have suggested that cigarette smoking is associated with facial wrinkling in white subjects.[6-9] However, to date, no report has investigated the effect of smoking on wrinkling in Asian skin. Therefore, we investigated the role of cigarette smoking and sun exposure on facial wrinkling in Koreans.

SUBJECTS AND METHODS

A total of 407 volunteers ranging in age from 30 to 92 years (236 men and 171 women) were involved in this study. The goal of participant recruitment was to enroll an approximately equal number of subjects, considering age, sex, sun exposure, and smoking history. To avoid selection bias, however, we accepted all subjects who volunteered during the study, because attempts to keep the groups of exactly equal size might lead to subconsciously choosing individuals with certain characteristics. For the recruitment of subjects 60 years and older we visited senior citizen centers (where these persons spend their time during the day) located in urban and rural areas. **Table 1** shows the distribution of study subjects by sex, age, sun exposure, and smoking status.

PHOTOGRAPHY

Standardized facial photographs (en face, side, and 45° oblique) of all volunteers were taken. To ensure a consistent standardized photograph, we used a specially designed stereotactic device in concert with a camera and a constant light source (Canfield Scientific, Inc, Fairfield, NJ). After removing all cosmetics and jewelry, the volunteers were instructed to keep their eyes closed while relaxing their face as much as possible. None of the subjects had ever had facial surgery or used tretinoin. All patients signed a consent form approved by the Institutional Review Board of Seoul National University Hospital, Seoul, South Korea.

PHOTOGRAPHIC SCALES

Three dermatologists (JHC, SHL, and CSY) met as a panel, discussed each of the 407 photographs of the volunteers, and selected 8 photographic standards for both sexes as representative examples of wrinkles. These were assigned grades 0 to 7, thus making an 8-point scale where 0 represents no wrinkles and 7 indicates severely wrinkled (**Figure 1**). For pigmentary changes, 6 photographic standards for both sexes were selected as representative examples of dyspigmentation and assigned grades 0 to 5, thus making a 6-point scale where 0 represents no dyspigmentation and 5 represents severely dyspigmented (**Figure 2**).

TESTING THE PHOTOGRAPHIC SCALES

To test the reliability of the newly developed photographic scales for wrinkling and dyspigmentation, 2 groups of judges were used. The first group consisted of the 3 dermatologists who had constructed the photographic scales; these judges functioned as a panel and assigned a consensus grade to each subject. The second panel of 12 judges (8 residents in our Department of Dermatology and 4 nonmedical persons) were asked individually to grade 2 sets (one for wrinkles, the other for dyspigmentation) of photographs of 50 subjects (25 men and 25 women) using the new photographic wrinkle and dyspigmentation scales. The results were used to determine interobserver reproducibility. None of the photographs used to establish the standards were among the sets of photographs tested. Two weeks later, the same second panel regraded the same sets of photographs using the same photographic wrinkle and dyspigmentation scales. These results were used to determine intraobserver reproducibility. Interobserver reproducibility meant that the consensus panel and an independent judge assigned the same grade. Intraobserver reproducibility meant that each independent judge assigned the same grade to the same subject 2 weeks later.

Interobserver and intraobserver reproducibility were analyzed and quantified using the κ coefficient,[11] a chance-corrected intraclass correlation coefficient with possible values ranging from –1 (complete disagreement) to 1 (complete agreement). Values greater than 0.75 are generally interpreted as indicating excellent agreement; values ranging from 0.40 to 0.75, fair to good agreement; and values less than 0.40, poor agreement.

EVALUATION OF WRINKLING AND DYSPIGMENTATION

The photographs of each subject were evaluated independently by 2 of the investigators (SHL and CSY), without knowing the subjects' interview responses or smoking histories. After both reviewers assigned each subject a wrinkle and a dyspigmentation grade, they compared grades. There was a high degree of agreement (>85%) between the judges on the severity of wrinkling and dyspigmentation.

Skin color is a risk factor for skin cancer and photoaging. The increase in facultative skin pigmentation above the constitutive level (the sun exposure index [SEI]) may be an indicator of individual lifetime sun exposure.[10] Therefore, we also measured the facultative and constitutive skin pigmentation and assessed the influence of constitutive skin color and SEI on wrinkling and dyspigmentation in Koreans.

RESULTS

USEFULNESS OF PHOTOGRAPHIC SCALES

The 3 dermatologists of the consensus panel assigned 50 consensus grades for wrinkling and dyspigmentation; all grades, with the exception of 0, included a similar number of subjects (data not shown). For wrinkling, agreement between the 12 individual judges and the consensus panel was scored for 30 to 45 (mean±SD, 38.8±4.9) of the 50 subjects undergoing evaluation, corresponding to κ values ranging from 0.51 to 0.88 (mean±SD, 0.72±0.12). For dyspigmentation, the agreement between individual judges and the consensus panel was scored for 30 to 40 (mean±SD, 35.8±3.3) of the 50 subjects, corresponding to κ values ranging from 0.48 to 0.73 (mean±SD, 0.62±0.08). These results indicate good interobserver reproducibility in both photographic scales.

Intraobserver reproducibility was determined by comparing grades assigned to each subject by the same judges after a 2-week interval. Intraobserver reproducibility was calculated for 12 individual judges. For wrinkling, consistent assignments were made in 31 to 44 (mean±SD, 38.6±4.4) of the 50 subjects, correspond-

Therefore, we determined that the grading of wrinkling and dyspigmentation severity by means of our new photographic scales was a reliable process. Interobserver differences were resolved by discussing and subsequently assigning a new grade to these subjects. To obtain risk estimates from the logistic regression model, it was necessary to classify each subject as wrinkled or not wrinkled. Those subjects with grade 4 or higher were considered wrinkled. For dyspigmentation, those subjects with grade 3 or higher were considered dyspigmented.

COUNTING HYPERPIGMENTED MACULES AND SEBORRHEIC KERATOSES

We counted the number of hyperpigmented macules and seborrheic keratoses on the face of individual subjects. Hyperpigmented macules were defined as well-defined, pigmented macular patches and could include solar lentigo, freckles, and spots of mottled hyperpigmentation. Seborrheic keratoses was defined as slightly elevated, sometimes verrucous, well-defined, pigmented papules and plaques. When the differentiation of flat seborrheic keratoses from hyperpigmented macules was difficult, we counted those lesions as hyperpigmented macules. Pigmented nevi and melasma were not included in these assessments.

COLLECTING DATA ABOUT SUN EXPOSURE, USE OF SUNSCREEN, AND SMOKING HISTORY

We collected data by interviewing each subject to estimate cumulative sun exposure (including occupational and recreational), use of sunscreen, and history of smoking.

Exposure to sunlight was measured as average hours per day spent in the sun during one's lifetime. Subjects were questioned about the time spent in the sun in spring, summer, and fall by decade of life. The average hours of lifetime sun exposure per day were then calculated. Cigarette smoking was quantified in pack-years (average number of packs per day multiplied by years of smoking), where 1 pack-year equals smoking 1 pack (20 cigarettes) per day for 1 year or half of a pack per day for 2 years. The volunteers in our study did not use sunscreen at all.

SKIN PIGMENTATION

Facultative skin pigmentation was measured objectively at a UV-exposed site (crow's-feet), and constitutive pigmentation was measured in the UV-unexposed upper inner arm skin with the use of a spectrophotometer (Dermaspectrophotometer; Cortec-Technology, Hadsund, Denmark). We did not measure skin pigmentation in areas with pigmentary lesions such as visible freckles or solar lentigines. The SEI was calculated as previously described,[10] using the following equation:

SEI = (Facultative Pigmentation – Constitutive Pigmentation)/Constitutive Pigmentation.

STATISTICAL ANALYSIS

Cigarette smoking and sun exposure, as the main predictor variables, were analyzed as a categorical variable (0-0.9, 1-29.9, or ≥30 pack-years and 1-2, 3-4, or ≥5 h/d, respectively). Facial wrinkling and dyspigmentation, the outcomes of interest, were assessed as dichotomous variables (wrinkle grade, mild [0-3] vs severe [≥4]; dyspigmentation grade, mild [0-2] vs severe [≥3]) and as continuous variables. We performed the *t* test to compare the pigmentary changes of men and women. One-way analysis of variance (ANOVA) was applied to observe the differences regarding the numbers of variables according to age, ie, the average number of hyperpigmented macules and seborrheic keratoses, constitutive and facultative skin pigmentation, and SEI. We used a logistic regression model controlling for confounding variables (including age, sex, and sun exposure) with the presence of mild or severe wrinkling as the outcome, to calculate prevalence odds ratios (POR) with 95% confidence intervals. The likelihood ratio test for trend was performed to assess the linear increase in the logit risk with exposure to the risk factor (eg, cigarette smoking, sun exposure, and sex). We also performed a correlation analysis to evaluate the relationship between age and each grade of wrinkle and dyspigmentation. Further analysis was performed between wrinkle and dyspigmentation grade, and between wrinkle grade and SEI. Statistical significance was defined as $P<.05$. All analyses were performed using SAS statistical software (SAS Institute Inc, Cary, NC).

ing to κ values ranging from 0.54 to 0.85 (mean±SD, 0.72±0.10). For dyspigmentation, consistent assignments were made in 34 to 44 (mean±SD, 38.0±2.7) of the 50 subjects, corresponding to κ values ranging from 0.57 to 0.84 (mean±SD, 0.60±0.07). These results indicate good intraobserver reproducibility in both photographic scales.

PATTERNS OF WRINKLES AND DYSPIGMENTATION BY SEX

Because our new photographic scales for wrinkles and dyspigmentation were developed separately for men and women, we investigated whether scales for men can be used for the assessment of photodamage in women, and vice versa. The photographs of all 236 men were regraded using the women's photographic wrinkle scale, and the photographs of the 171 women were regraded using the men's photographic wrinkle scale. Consistent agreements were achieved in 117 (68%) of the 171 women and 185 (78%) of the 236 men, corresponding to κ values of 0.62 and 0.74, respectively. Disagreement occurred within 1 grade. These results indicate that our photographic wrinkle scales for men and women are interchangeable and that the pattern of wrinkles is similar in both sexes.

Because our photographic scale of dyspigmentation primarily represents the areas of dyspigmentation, and dyspigmentation usually appeared with hyperpigmented macules and seborrheic keratoses, we also counted the number of hyperpigmented macules or seborrheic keratoses. **Table 2** shows the average number of hyperpigmented macules and seborrheic keratoses in all age groups of both sexes. The number of hyperpigmented

Table 1. Distribution of 407 Study Subjects by Sex, Age, Sun Exposure, and Smoking*

Sex; Age, y	No. of Subjects (%)	Sun Exposure, h/d†			Smoking, Pack-years‡		
		1-2	3-4	≥5	0-0.9	1-29.9	≥30
Men							
30-49	43 (18.2)	28 (65.1)	14 (32.6)	1 (2.3)	21 (48.8)	18 (41.9)	4 (9.3)
50-69	67 (28.4)	10 (14.9)	14 (20.9)	43 (64.2)	11 (16.4)	23 (34.3)	33 (49.3)
≥70	126 (53.4)	9 (7.1)	22 (17.5)	95 (75.4)	19 (15.1)	38 (30.2)	69 (54.8)
Subtotal	236 (58.0)	47 (19.9)	50 (21.2)	139 (58.9)	51 (21.6)	79 (33.5)	106 (44.9)
Women							
30-49	14 (8.2)	12 (85.7)	2 (14.3)	0	14 (100)	0	0
50-69	82 (48.0)	21 (25.6)	4 (4.9)	57 (69.5)	74 (90.2)	8 (9.8)	0
≥70	75 (43.9)	19 (25.3)	6 (8.0)	50 (66.7)	55 (73.3)	12 (16.0)	8 (10.7)
Subtotal	171 (42.0)	52 (30.4)	12 (7.0)	107 (62.6)	143 (83.6)	20 (11.7)	8 (4.7)
Total	**407 (100)**	**99 (24.3)**	**62 (15.2)**	**246 (60.4)**	**194 (47.7)**	**99 (24.3)**	**114 (28.0)**

*Data were obtained from a Korean sample, 1999; data are given as number (percentage) of subjects. Percentages have been rounded and may not sum 100.
†Indicates average hours per day spent in the sun during lifetime.
‡Determined by multiplying average number of packs smoked per day by years of smoking.

Figure 1. Photographic scale used to grade the overall severity of facial wrinkles. Two sets of 8 serial photographs depict the grade of wrinkling in women (A) and men (B). Eight photographic standards illustrate increasing severity of wrinkles, where 0 represents none; 1, none/mild; 2, mild; 3, mild/moderate; 4, moderate; 5, moderate/severe; 6, severe; and 7, very severe.

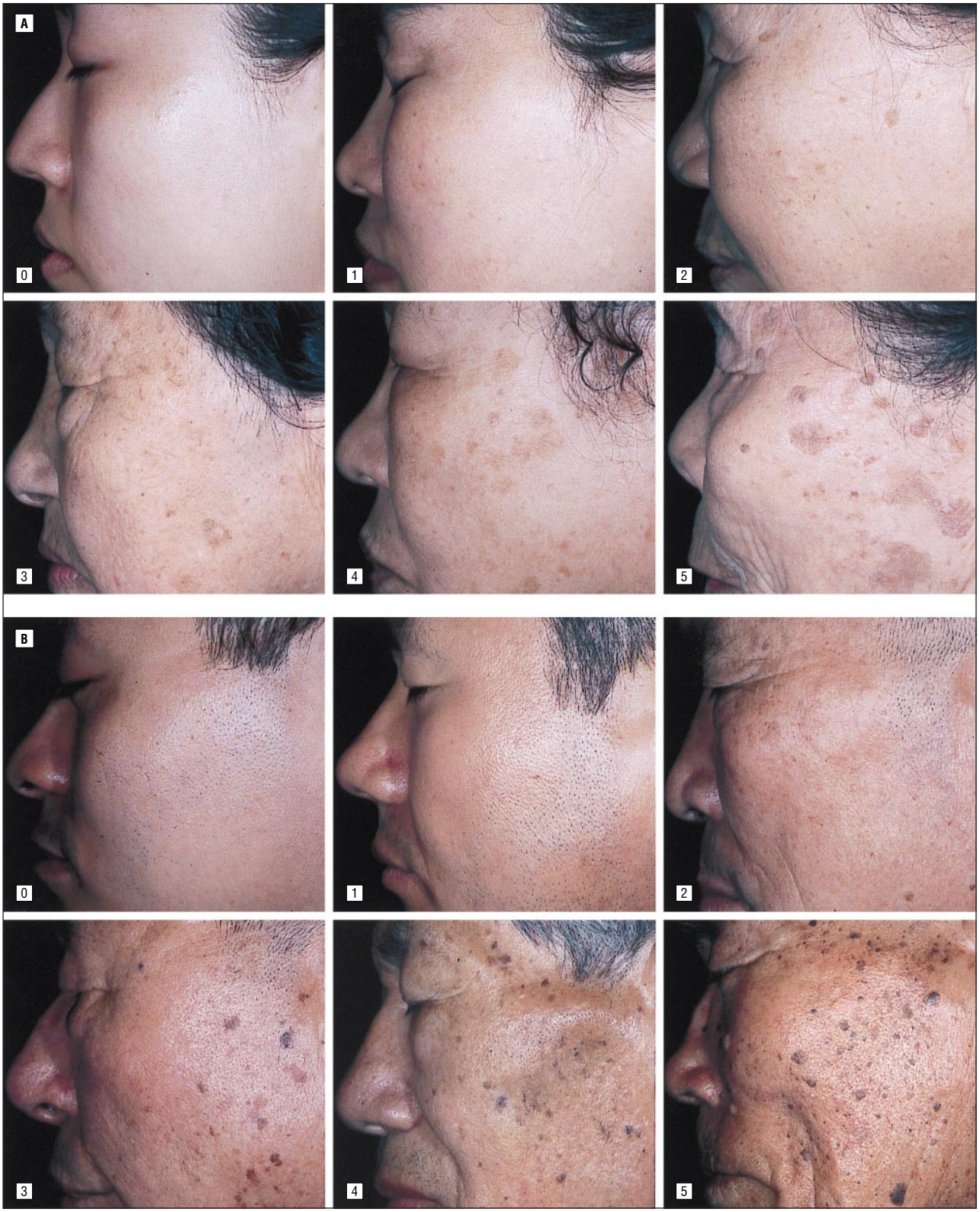

Figure 2. Photographic scale used to grade the overall severity of facial dyspigmentation. Two sets of 6 serial photographs depict the grade of dyspigmentation in women (A) and men (B). Six photographic standards illustrate increasing severity of dyspigmentation, where 0 represents none; 1, mild; 2, mild/moderate; 3, moderate; 4, moderate/severe; and 5, severe.

macules and seborrheic keratoses increased with each decade of age ($P<.05$, ANOVA). In those 60 years and older, seborrheic keratosis was more common in men than in women ($P<.001$, t test). On the other hand, in those 50 years and older, hyperpigmented macules were found more frequently in women than in men ($P<.01$, t test). Our results demonstrated that the pattern of dyspigmentation differs between sexes.

Table 2. Average Number of Hyperpigmented Macules and Seborrheic Keratosis*

Age, y	No. of Subjects		Hyperpigmented Macules			Seborrheic Keratoses		
	Men	Women	Men†	Women‡	*P*§	Men†	Women†	*P*§
30-39	25	3	6.0 ± 5.0	4.3 ± 7.5	.86	0.1 ± 0.6	0	.76
40-49	18	11	15.8 ± 10.3	18.9 ± 7.0	.61	2.7 ± 2.8	2.5 ± 3.0	>.99
50-59	30	38	14.4 ± 6.7	23.5 ± 13.8	.006	4.6 ± 4.3	4.6 ± 3.0	.38
60-69	37	44	13.1 ± 8.4	22.2 ± 10.7	.006	11.5 ± 12.4	5.1 ± 4.0	.001
≥70	126	75	18.0 ± 10.8	25.1 ± 13.3	<.001	13.6 ± 11.2	8.9 ± 9.7	<.001
Total	**236**	**171**	15.4 ± 10.1	23.3 ± 12.6		9.9 ± 10.9	6.2 ± 7.4	

*Unless otherwise indicated, values are given as mean ± SD.
†$P<.001$, analysis of variance.
‡$P=.04$, analysis of variance.
§Comparison between men and women of same age by *t* test.

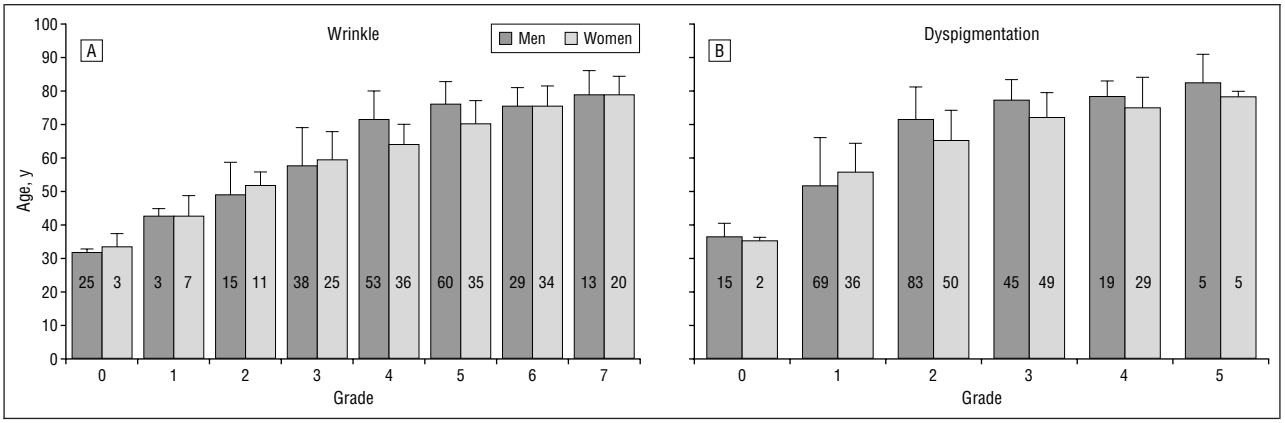

Figure 3. The mean ages of each grade of wrinkle and dyspigmentation in Koreans, 1999. Statistical analysis was performed by means of the Spearman test. Significant correlations of age with each grade were found for the wrinkle (A) and dyspigmentation grades (B) ($P<.001$, $r=0.71$ [male wrinkles]; $P<.001$, $r=0.78$ [female wrinkles]; $P<.001$, $r=0.76$ [male dyspigmentation]; and $P<.001$, $r=0.63$ [female dyspigmentation]). Grading is described in the legends to Figures 1 and 2. Numbers in bars indicate the number of subjects.

CORRELATION BETWEEN WRINKLES AND DYSPIGMENTATION

Many investigators have thought that wrinkles are the prominent feature of photodamage in white subjects, whereas in Asian skin, dyspigmentation is the major manifestation. However, no extensive studies have confirmed this belief.

Therefore, we investigated the relationships between wrinkling and dyspigmentation in Korean skin. **Figure 3** shows the mean ages of the subjects according to the grade of wrinkles and dyspigmentation. In general, significant age-related changes of grades in wrinkling and dyspigmentation were found ($P<.001$, Spearman test). There were rapid increases of the mean age until grade 4 for wrinkling and grade 3 for dyspigmentation, and then the increase of the mean age slowed.

After controlling for age and sex, a significant relationship was found between the grades of wrinkling and dyspigmentation (**Figure 4**), with the exception of men 70 years and older (for whom wrinkles and dyspigmentation are so severe that it may be impossible to show any correlation) and women aged 30 to 49 years (because the wrinkling and pigmentary changes were still mild, or the number of volunteers was small).

EFFECTS OF SMOKING AND SUN EXPOSURE ON WRINKLES AND DYSPIGMENTATION

Cigarette smoking was present in 194 subjects ranging from 0 to 0.9 pack-years and in 213 subjects ranging from 1 to 120 pack-years. We developed a logistic model to analyze the association of smoking, sex, and sun exposure with the development of excessive wrinkling (**Table 3**). After controlling for age, sex, and sun exposure, we found an association between cigarette smoking and wrinkling that showed a significant trend with increasing pack-years. The POR of wrinkling associated with smoking in subjects with smoking histories of 30 and 50 pack-years were 2.8 and 5.5, respectively.

As expected, we confirmed an association between exposure to the sun and the development of wrinkling (Table 3). After controlling for age and sex, sun exposure of more than 5 hours per day was associated with a 4.8-fold increased risk for wrinkling, compared with 1 to 2 hours per day.

The interaction between the effects of sun exposure and cigarette smoking on wrinkling is shown in **Table 4**. Sun exposure of more than 5 hours per day and a smoking history of more than 30 pack-years (when controlled for age and sex) were associated with a 4.2-fold increased risk for wrinkling, compared with a 2.2-fold increase for nonsmokers with 1 to 2 hours per day of sun exposure.

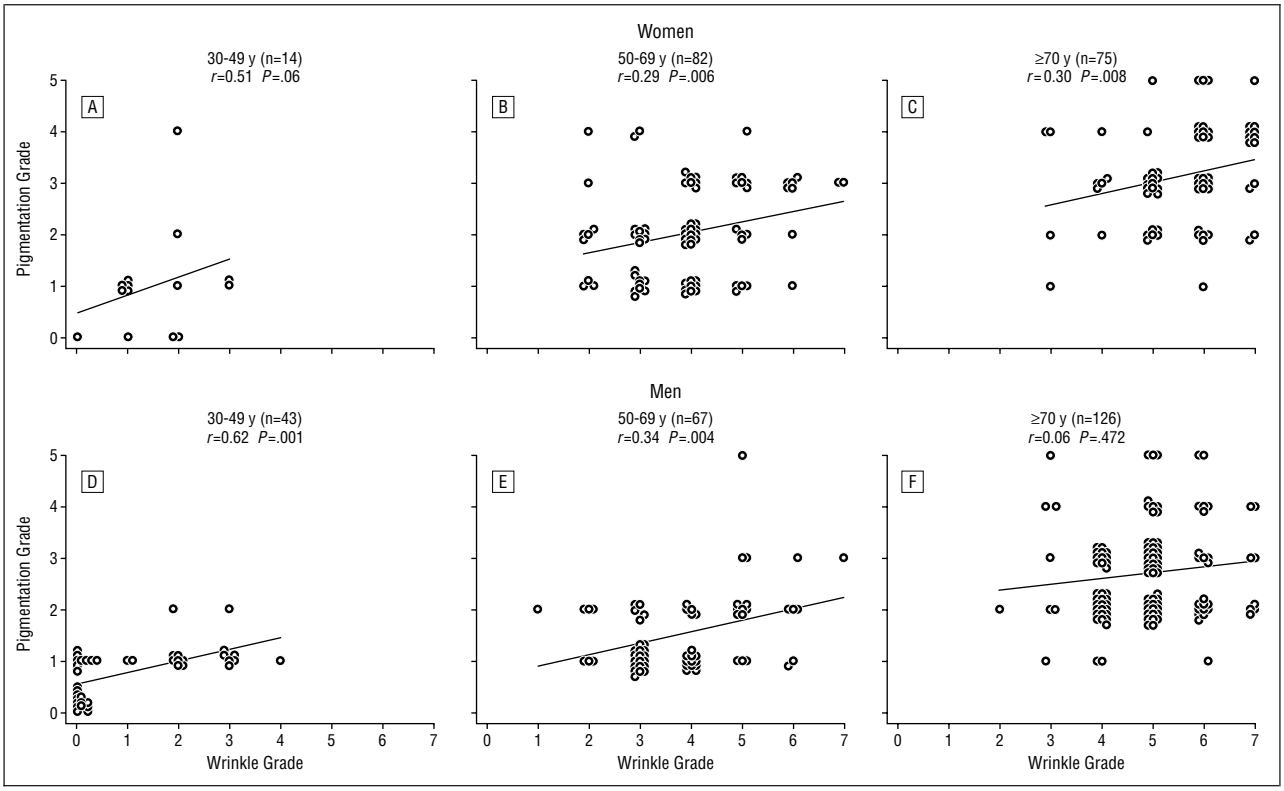

Figure 4. The relationship between wrinkle grade and pigmentation grade in Koreans, 1999. Statistical analysis was performed by means of the Spearman test. Significant correlations of pigmentation grade with wrinkle grade were found for women aged 50 to 69 years (B) and 70 years and older (C), and for men aged 30 to 49 years (D) and 50 to 69 years (E). Grading is described in the legends to Figures 1 and 2.

Table 3. Prevalence Odds Ratios for Severe Wrinkling Adjusted for Age, Sex, Smoking, and Sun Exposure

Characteristic	Wrinkled Subjects, No. (%)*	Prevalence Odds Ratio (95% CI)†	*P* for Trend‡
Cigarette smoking, pack-years§			
0-0.9	194 (40.7)	1.00	
1-29.9	99 (40.4)	1.50 (0.69-3.27)	
≥30	114 (63.2)	2.83 (1.25-6.44)	.009
≥50	54 (79.6)	5.53 (1.96-15.60)	.002
Sun exposure, h/d‖			
1-2	99 (19.2)	1.00	
3-4	62 (21.1)	0.84 (0.31-2.24)	
≥5	246 (64.6)	4.85 (2.35-10.17)	<.001
Sex			
Men	236 (43.2)	1.00	
Women	171 (52.1)	3.69 (1.74-7.84)	<.001

*Defined as a wrinkle grade ≥4. Grading is described in the legend to Figure 1.
†Adjusted for age, sex, smoking, and sun exposure as appropriate. CI indicates confidence interval.
‡Determined by likelihood ratio test.
§Determined by multiplying average number of packs smoked per day by years of smoking.
‖Indicates average hours per day spent in the sun during lifetime.

Table 4. Prevalence Odds Ratios for the Independent and Combined Effects of Cigarette Smoking and Sun Exposure on Wrinkles

Combinations of Smoking and Sun Exposure*	Wrinkled Subjects, No. (%)†	Prevalence Odds Ratio (95% CI)‡	*P* for Trend§
Neither present	88 (20.5)	1.00	<.001
Smoking only	24 (33.3)	2.20 (0.59-8.24)	
Sun exposure only	106 (57.6)	4.19 (1.91-9.22)	
Both present	90 (71.1)	10.78 (3.67-31.63)	

*Defined as smoking history of ≥30 pack-years and sun exposure time of ≥5 hours per day. Both risk factors are explained in the fourth and fifth footnotes to Tables 1 and 3.
†Defined as wrinkle grade of ≥4. Grading is described in Figure 1.
‡Adjusted for age and sex as appropriate. CI indicates confidence interval.
§Determined by likelihood ratio test.

The combined effect of these 2 variables was multiplicative (POR, 10.8). In this study, however, there was no significant association observed between smoking and dyspigmentation (data not shown).

After controlling for age, sun exposure, and smoking, there was a greater risk for development of wrinkles observed in women (POR, 3.7) than in men (Table 3). Because we graded the severity of wrinkles separately by sex, these results may reflect a difference in the grading scales themselves. Therefore, we regraded the wrinkle severity of all subjects by using the grading scale for the opposite sex, and reanalysis produced a similar POR (men's scale, 2.8; women's scale, 3.4) (data not shown).

RELATIONSHIPS OF SKIN COLOR WITH WRINKLING AND DYSPIGMENTATION

The individual increase in facultative pigmentation expressed as a percentage of constitutive skin pigmentation may be an objective indicator of lifetime sun expo-

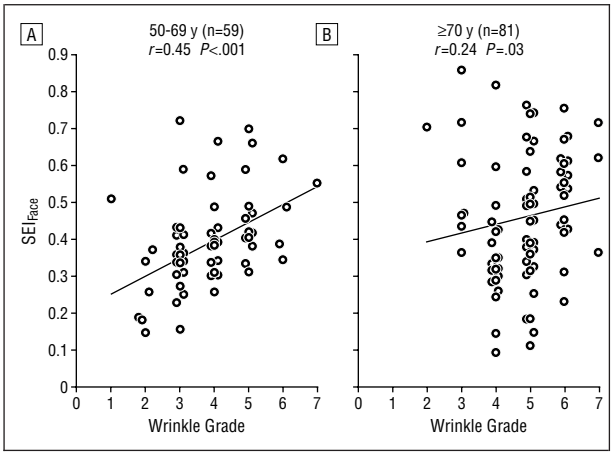

Figure 5. The relationship between wrinkle grade and sun exposure index for the face (SEI_{Face}) in men. Statistical analysis was performed by means of the Spearman test. Significant correlations of SEI_{Face} with wrinkle grade were found for men aged 50 to 69 years (A) and 70 years and older (B). Wrinkle grading is described in legend to Figure 1; SEI, in the "Skin Pigmentation" subsection of the "Subjects and Methods" section.

sure.[10] In this study, we demonstrated that the SEI was correlated significantly with sun exposure in both sexes ($P<.05$, Pearson correlation) (data not shown), with the exceptions of men aged 30 to 49 years and women 70 years and older. Although these 2 groups did not show a statistical correlation, they showed a tendency of correlation. The facultative pigmentation and SEI increased significantly with age in both sexes ($P<.01$, ANOVA) (data not shown). Furthermore, we demonstrated that there was a general tendency of correlation between increased SEI and wrinkle severity. There is a significant correlation, particularly in men aged 50 to 69 years ($P<.001$) and 70 years and older ($P=.03$) (**Figure 5**). However, after controlling for age, sex, and sun exposure, there was no correlation seen between constitutive pigmentation and wrinkles (data not shown).

After controlling for age, sex, and sun exposure, there was also no correlation observed between dyspigmentation severity and constitutive pigmentation or SEI in all age groups of both sexes (data not shown).

COMMENT

We have developed new photographic scales for the evaluation of photoaging in Korean skin. Previously, Griffiths et al[3] and Larnier et al[4] developed similar photographic scales for the evaluation of the characteristic features of photoaging in female white subjects. They have tried to assess completely the photodamage in each individual, represented by a single score. Because of the difficulty of quantifying different features of photoaging such as wrinkling and pigmentary changes in the same individual into a single score, we developed separate grading systems for wrinkling and dyspigmentation for both sexes of Koreans. In our study, these photographic scales provided consistent and reproducible clinical evaluations of photodamage severity in Koreans. There was good interobserver and intraobserver reproducibility in the test, and the disagreements that occurred were always within one grade. These results indicate that these new photographic scales can be used by clinicians without special training in photoaging.

We developed separate photographic scales for both sexes and then subjected each sex to testing with the other's scales. We found that the photographic wrinkle scales for both sexes can be applied to the opposite sex without significant differences from the test results obtained using their own sex-specific scale. This indicates that the pattern of wrinkling in both sexes is very similar. However, to our surprise, there was a greater risk for development of wrinkles in women than in men, after controlling for age, sun exposure, and smoking. The reasons why women show more wrinkles remain to be investigated. Skin collagen content declines because of hypoestrogenism after menopause.[12,13] Recently, markedly reduced collagen levels due to chronic sun exposure have been believed to be responsible for wrinkle formation in photoaged skin.[14,15] Thus, the decrease of skin collagen content because of estrogen deficiency in postmenopausal women may aggravate the severity of wrinkles due to aging and sun exposure.

The patterns of pigmentary changes in both sexes are different. In men, seborrheic keratosis tends to be more prominent, whereas in women, hyperpigmented macules are more prominent. The reasons for this discrepancy need to be investigated.

Many investigators believe that the prominent clinical signs of photoaging in Asians include pigmentary changes, which are an early and prominent feature, whereas wrinkling is a late and inconspicuous feature. Goh[2] reported that wrinkling in Asians is not noticeable until about 50 years of age and, even then, the degree is not as marked as in white subjects of a similar age. However, we found that wrinkling is also a prominent feature of cutaneous photodamage in Asians. In this study, wrinkles of more than grade 2 or 3 severity became apparent around 50 years of age. We demonstrated a statistically significant association between wrinkling grades and dyspigmentation grades. These results suggest that wrinkling and pigmentary changes are major features of photoaging in Asians.

Smoking causes premature aging and wrinkling of the face in white subjects.[6-9] However, until now, there had not been a study of Asian skin. To our knowledge, this study is the first to demonstrate the relationship between cigarette smoking and wrinkling in Asians. We found a similar POR of 50 pack-years between smoking and wrinkling as that seen in white subjects, as reported by Kadunce et al.[7] We also confirmed the relationship of sun exposure with wrinkling in Asian skin. The effects of cigarette smoking and excessive sun exposure on wrinkling were multiplicative.

In this study, we assessed wrinkling by evaluating photographs so that the degree of wrinkling could be assessed without knowledge of the subject's smoking status. The application of a logistic model allowed us to treat smoking as a continuum of exposure. The logistic model compared heavy smokers (>30 pack-years) with nonsmokers (<0.9 pack-years) and with light smokers (1-29 pack-years), permitting the identification of the increasing risk for wrinkling with increased pack-years of cigarette smoking. For many years, biological aging and sun

exposure have been accepted as contributing to the pathogenic insults that result in wrinkling. We have shown that cigarette smoking is also an independent risk factor for the development of wrinkles in Asians, as in white subjects. Furthermore, the detrimental effects of smoking are additive to those induced by aging and sun exposure in Asians.

Skin color is one of the risk factors for skin aging and skin cancer. In white subjects, the incidence of skin cancers and the severity of wrinkles are greater than in black subjects. The brown skin of Asians seems to be between white and black skin. It has been suggested that in white skin, the increase in facultative skin pigmentation above the constitutive level (the SEI) might be an indicator of individual lifetime sun exposure.[10]

We demonstrated that the facultative pigmentation, but not the constitutive pigmentation, increased with age in the facial region. The SEI demonstrated a positive correlation with the history of sun exposure in both sexes in the brown skin of Koreans. In this study, after controlling for age and sex, we found that SEI has a positive correlation with the severity of wrinkling, with a particularly significant correlation in men aged 50 to 69 years and 70 years and older. However, there was no correlation of the severity of dyspigmentation with SEI. The reason why only wrinkle grade, but not dyspigmentation grade, demonstrated a positive correlation with SEI is not known. There are 2 possibilities. First, SEI may not be a sufficient indicator of lifelong sun exposure, and second, the facultative skin color of Asians may plateau early in their lives. The severity of wrinkling and dyspigmentation did not show any correlation with constitutive pigmentation in Koreans (data not shown). This is because the skin type of Koreans is relatively uniform and usually belongs to Fitzpatrick skin types IV and V.

In conclusion, wrinkling is a major feature of photoaging in Asians, as are pigmentary changes. Smoking, sun exposure, and female sex are independent risk factors for wrinkles in Asians.

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