

Facial Changes Caused by Smoking: A Comparison between Smoking and Nonsmoking Identical Twins

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Background: The purpose of this study was to identify the specific components of facial aging secondary to smoking, by comparing standardized photographs of identical twins with different smoking histories.

Methods: During the Twins Days Festival in Twinsburg, Ohio, from 2007 to 2010, 79 pairs of twins were identified, in which only one twin smokes or where one twin smoked at least 5 years longer than his or her counterpart. Questionnaires were obtained and standardized photographs were taken by professional photographers. A panel of three blinded judges analyzed the twins' facial features and graded wrinkles using the validated Lemperle Assessment Scale, and ranked age-related facial features on a four-point scale.

Results: Smoking twins compared with their nonsmoking counterparts had worse scores for upper eyelid skin redundancy, lower lid bags, malar bags, nasolabial folds, upper lip wrinkles, lower lip vermilion wrinkles, and jowls. Lower lid hyperpigmentation in the smoking group fell just short of statistical significance. Transverse forehead wrinkles, glabellar wrinkles, crow's feet, and lower lip lines accentuated by puckering did not have a statistically significant differences in scores. Among twins with greater than 5 years' difference in smoking duration, twins who had smoked longer had worse scores for lower lid bags, malar bags, and lower lip vermilion wrinkles.

Conclusions: This study details the specifics of facial aging brought on by smoking, which primarily affects the middle and lower thirds of the face. It also demonstrates that a 5-year difference in smoking history can cause noticeable differences in facial aging in twins. (*Plast. Reconstr. Surg.* 132: 1085, 2013.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Risk, II.

Some individuals appear older than their actual age. The main causes of this accelerated senescence are often unclear. Through studies on twins, our group and others have identified some of the factors that contribute to premature aging. These include sun exposure, smoking, drinking, weight loss after age 40, weight gain before age 40, and being on antidepressant medications.¹ Other studies have also shown repeatedly that smoking is an independent lifestyle factor associated with facial aging,²⁻⁴ and there are molecular mechanisms of tobacco on dermal fibroblasts. However, there has been

a relative paucity of publications that include facial analysis of smokers to determine what parts are affected the most by smoking. We capitalized on the unique opportunity to gather medical and lifestyle histories and photographic data of identical twins at the annual Twins Days Festival in Twinsburg, Ohio, and designed this study to examine the aging effects of smoking on the faces of identical twins.

SUBJECTS AND METHODS

The Twins Days Festival is an annual gathering of twins and multiples in Twinsburg, Ohio. The Department of Plastic Surgery at Case Western Reserve University obtained comprehensive

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Fig. 1. The twin on the *left* has smoked 17 years longer than the twin on the *right*. Note the differences in lower lid bags and upper and lower lip wrinkles.

medical and lifestyle histories of twins by means of questionnaire at the festival between 2007 and 2010. Professional photographers took standardized digital photographs of the participants in outdoor booths with overhead shades

(Figs. 1 through 4). Consent was obtained from all participating twins, and this study was commenced with institutional review board approval.

The questionnaires completed by 412 twins (96 in 2007; 114 in 2008; 84 in 2009, and 118 in



Fig. 2. Both twins are smokers. The twin on the *right* smoked 14 years longer than his brother.



Fig. 3. The twin on the *right* is a smoker; the twin on the *left* is a nonsmoker. Notice differences in nasolabial creases.

2010) who were 18 years and older were used in this study. From these, we identified 79 sets of twins who met the following inclusion criteria: within a twin set, one twin was a smoker and the other had never smoked, or within a twin set both

were smokers with at least a 5-year difference in duration of smoking (Table 1). We opted to use a 5-year difference rather than pack-years, as patients remembered their age when they began smoking, but were not always able to accurately



Fig. 4. The twin on the *left* is a nonsmoker and the twin on the *right* smoked for 29 years. Note the differences in periorbital aging.

Table 1. Twin Characteristics

Characteristic	Value (%)
No. of twin sets	79
Age, yr	
Mean	48.3
Range	18–78
Sex	
Male	22 (28)
Female	57 (72)
Body mass index, kg/m ²	
Mean	27.8
Range	19.0–53.9

recall the number of cigarettes consumed per day. Excluded were minors (younger than 18 years), nonsmoking twins, twins with less than a 5-year difference in years of smoking, or those with incomplete questionnaires regarding their smoking history. The study pool was further separated into two different groups. Group A included 45 sets of twins with only one smoker and a nonsmoker counterpart, and group B encompassed 34 sets of twins where both smoked but one twin smoked 5 years more than the other (Table 2). In addition, judges were asked to select which twin appeared globally older, based on the twins' frontal facial photographs.

Photographs were size-matched using Mirror software (Canfield Scientific, Inc., Fairfield, N.J.). A panel of three blinded judges (H.C.O., B.A., and K.K.) was trained to evaluate wrinkles using the Lemperle Assessment Scale. Frontal views of each twin set were arranged side by side and randomized by a nonjudge (K.V.) so that the smoker or smoker of longer duration appeared sometimes on the left side and other times on the right. The judges then independently analyzed the twins' photographs for the following features (Table 3). For the forehead, transverse and vertical (glabellar) wrinkles were assessed separately on a scale ranging from 0 to 5 using the validated Lemperle Assessment Scale,^{5,6} with 5 being the deepest and 0 being the shallowest wrinkle. For periorbital aging, the following was assessed: crow's feet (0 to 5), upper lid skin redundancy (0 to 3; none, mild, moderate, and

severe), lower lid skin discoloration (0 to 3), lower lid bags (0 to 3), and the presence of malar bags/festoons (0 to 3). For the perioral area, upper nonvermillion lip wrinkles were assessed on repose and pucker (0 to 5), and lower vermillion lip wrinkles were assessed on repose alone (0 to 3). In addition, the jowls (0 to 3) and nasolabial creases (0 to 5) were scored. The Lemperle Assessment Scale was used wherever possible in the analysis, and all other areas were graded on a scale ranging from 0 to 3 (none, mild, medium, and severe). Seven sets of men were excluded from the analysis of upper lip wrinkle assessment because of excessive facial hair.

For statistical analysis, the scores for each independent variable were analyzed using GraphPad InStat version 3.05 (GraphPad Software, Inc., San Diego, Calif.) and were considered significant based on a 95 percent confidence interval ($p < 0.05$). Data were expressed as means \pm SD. Differences in the groups were compared using the Kruskal-Wallis test (nonparametric analysis of variance) followed by the Dunn multiple comparisons test for variables containing a value of $p < 0.05$.

RESULTS

Of the 79 sets of twins, 57 sets (72 percent) were female. The mean age of the patients was 48.3 years (range, 18 to 78 years), and the mean body mass index was 27.8 kg/m² (range, 19.0 to 53.9 kg/m²). We also found that the groups of twins were well matched for body mass index. Smokers had a mean body mass index of 27.3 kg/m² and nonsmokers had a mean body mass index of 27.0 kg/m² ($p = 0.77$), and the difference was not significant, as determined by the *t* test.

To confirm that the smokers' and nonsmokers' environmental aging factors were properly controlled for, a Mann-Whitney test was performed on their sunscreen use, alcohol intake, and perceived work stress. Alcohol use was scored as 0 points for abstinence, 1 point for one to two drinks per week, 2 points for three to four drinks per week, 3 points for five to six drinks per week, 4 points for seven to eight drinks per week, 5 points for nine to 10 drinks per week, and 6 points for more than 10 drinks per week. The mean alcohol intake score was 0.77 ± 0.43 for smokers and 0.72 ± 0.53 for nonsmokers ($p = 0.74$). Stress at work was graded as 0 points for none, 1 point for minimal, 2 points for moderate, and 3 points for severe stress. The mean stress score was 1.3 ± 0.75 for smokers and 1.5 ± 0.82 for nonsmokers ($p = 0.28$). For

Table 2. Smoking History

Group	Smoking History
A	One twin smokes
B	Both smoke, but one twin smokes at least 5 yr longer
Excluded	Neither smoke or both smoke with <5-yr difference in duration, or age younger than 18 yr

Table 3. Facial Feature Analysis Sheet

Facial Feature	Score on Wrinkle Assessment Scale (0–5)					
	0	1	2	3	4	5
Forehead transverse lines	0	1	2	3	4	5
Forehead glabellar lines	0	1	2	3	4	5
Crow’s feet	0	1	2	3	4	5
Upper lip lines (repose)	0	1	2	3	4	5
Upper lip lines (pucker)	0	1	2	3	4	5
Nasolabial crease	0	1	2	3	4	5

Facial Feature	Score on 0–3 Scale (None, Mild, Moderate, and Severe)			
	0	1	2	3
Upper lid skin redundancy	0	1	2	3
Lower lid pigmentation	0	1	2	3
Lower lid bags	0	1	2	3
Malar bags	0	1	2	3
Lower lip vermilion lines	0	1	2	3
Jowls	0	1	2	3

sun protection, subjects were assigned 0 points for stating no sunscreen use and 1 point for sunscreen use. Smokers had a mean sunscreen use score of 0.76 ± 0.43 and nonsmokers scored 0.76 ± 0.43 ($p = 0.99$). Thus, the differences in smokers’

and nonsmokers’ sunscreen use, alcohol intake, and perceived work stress were not statistically different.

We found that the smoking twin compared with their nonsmoking counterpart had worse scores for upper eyelid skin redundancy, lower lid bags, malar bags, nasolabial creases, jowls, upper lip lines (smoker’s lines) on repose, and lower lip vermilion lines (Table 4). Among these, lower lid bags, malar bags, and lower lip vermilion lines were most statistically significant ($p < 0.0001$). Transverse forehead lines, glabellar lines, crow’s feet, and upper lip lines accentuated by puckering did not have a statistically significant difference in scores. There was a strong trend of lid hyperpigmentation among smokers ($p = 0.06$), although it fell short of statistical significance defined by a value of $p < 0.05$.

Among smoking twins with at least a 5-year difference in duration of smoking, the mean difference in smoking duration was 13 years. Twins who had smoked longer had statistically worse

Table 4. Wrinkle Scores for Group A: Smokers versus Nonsmokers

Category	Smoker	Nonsmoker	<i>p</i>
Transverse forehead lines (0–5)			0.18
Average	1.73	1.76	
SD	1.44	1.25	
Glabellar lines (0–5)			0.90
Average	1.53	1.64	
SD	1.34	1.46	
Crow’s feet (0–5)			0.78
Average	1.97	1.97	
SD	1.42	1.44	
Upper lid skin redundancy (0–3*)			0.02
Average	1.56	1.51	
SD	0.88	0.84	
Lower lid pigmentation (0–3*)			0.06
Average	1.21	1.15	
SD	0.87	0.82	
Lower lid bags (0–3*)			<0.0001
Average	0.64	0.67	
SD	0.82	0.85	
Malar bags (0–3*)			<0.0001
Average	0.38	0.35	
SD	0.71	0.62	
Upper lip vertical lines (0–5)			0.005
Average	1.35	1.13	
SD	1.40	1.15	
Upper lip lines while puckering (0–3*)			0.45
Average	1.38	1.32	
SD	0.96	0.91	
Lower lip vermilion lines (0–3*)			<0.0001
Average	1.38	1.25	
SD	0.84	0.72	
Nasolabial crease (0–5)			0.018
Average	2.19	2.16	
SD	1.44	1.34	
Jowls (0–3*)			0.048
Average	1	0.93	
SD	1.01	0.94	

*0 = none, 1 = mild, 2 = moderate, and 3 = severe.

Table 5. Wrinkle Scores for Group B: Twins with a Greater Than 5-Year Difference in Smoking History

Category	Smoke Less	Smoke >5 Yr More	<i>p</i>
Transverse forehead lines (0–5)			0.78
Average	2	2.23	
SD	1.37	1.64	
Glabellar lines (0–5)			>0.99
Average	1.45	1.44	
SD	1.37	1.33	
Crow's feet (0–5)			0.89
Average	2	2.12	
SD	1.41	1.43	
Upper lid skin redundancy (0–3*)			0.32
Average	1.66	1.69	
SD	0.86	0.90	
Lower lid pigmentation (0–3*)			0.06
Average	1.15	1.35	
SD	0.84	0.86	
Lower lid bags (0–3*)			<0.0001
Average	0.73	0.75	
SD	0.90	0.88	
Malar bags (0–3*)			<0.0001
Average	0.39	0.42	
SD	0.70	0.69	
Upper lip vertical lines (0–5)			0.37
Average	0.95	1.46	
SD	1.07	1.59	
Upper lip lines while puckering (0–3*)			0.47
Average	1.25	1.44	
SD	0.86	1.06	
Lower lip vermilion lines (0–3*)			0.0021
Average	1.14	1.43	
SD	0.73	0.95	
Nasolabial crease (0–5)			0.28
Average	2.33	2.35	
SD	1.32	1.49	
Jowls (0–3*)			0.31
Average	1.11	1.23	
SD	1.01	1.10	

*0 = none, 1 = mild, 2 = moderate, and 3 = severe.

scores for lower lid bags, malar bags, and lower lip vermilion lines (Table 5). There were no differences for forehead lines, glabellar lines, crow's feet, upper lid skin redundancy, upper lip lines when puckered, nasolabial creases, or jowls. Here also, there was a tendency for lower lid hyperpigmentation in smokers of longer duration ($p = 0.06$).

An interrater reliability analysis using the κ statistic was performed to determine consistency among judges. The interrater reliability for the judges was found to be $\kappa = 0.782$ ($p < 0.0001$; 95 percent CI, 0.474 to 1.090). A κ value of 0.61 to 0.80 signifies substantial interrater agreement.

For the global assessment of the face, the smoking twin was identified as appearing older 57 percent of the time ($p = 0.0048$, Mann-Whitney-Wilcoxon test). For twin sets in which both were smokers, the twin who smoked more than 5 years longer than the counterpart was identified as appearing older 63.7 percent of the time ($p = 0.0063$).

DISCUSSION

The deleterious effects of smoking have long been recognized. Daniell first established the link between periorbital premature aging and smoking in 1971.⁷ Subsequent reports examined the effects of smoking on facial aging, and have demonstrated worsening wrinkling with increased number of pack-years.⁸ There has also been a previous study published by the dermatology department at our institution that described a twin pair that had a similar type of job and lived at the same latitude, with a 52.5-pack-year smoking history difference and with marked changes in facial aging.⁹ The negative facial changes attributable to smoking can even be seen after a face lift, as seen in the study by Alpert et al. of twins undergoing simultaneous face-lift procedures.¹⁰ At the molecular level, research has shown that smoking is an exogenous source of free radicals that may impair the repair mechanisms in the skin, and that it alters the extracellular matrix turnover by down-regulating collagen and elastin synthesis.¹¹

To our knowledge, our article is the first of its kind to analyze faces of a large series of monozygotic twins with a difference in smoking histories. Starting at the upper third of the face, we found no differences in wrinkle severity for the transverse lines of the forehead or the vertical glabellar lines. Similarly, there were no differences in the depth of crow's feet. We interpreted these results as indicating that lines in these areas may be caused primarily by the dynamic contraction of mimetic muscles¹² rather than the deleterious effects on the skin resulting from smoking.

In contrast, periorbitally, there were worse scores for lower lid bags and malar bags in smokers compared with nonsmokers and in the twins who had a longer duration of smoking compared with their counterparts. The lower lid bags could be attributed to a decrease in integrity of the delicate orbital septum, leading to fat herniation. A study by Yin et al. demonstrated that when human fibroblasts *in vitro* were exposed to increasing concentrations of water-soluble tobacco extract, their expression of matrix metalloproteinases 1 and 3 increased in a dose-dependent manner.¹³ Also, collagen I and collagen III biosynthesis was significantly reduced after exposure to tobacco extract. It could be that the increased catabolism of connective tissue from the metalloproteinases, coupled with the impaired collagen synthesis, disrupts the maintenance of delicate connective tissue structures such as the orbital septum, leading to the appearance of lower lid bags in the smoker. In addition, the weakness of the orbital septum can make the appearance of lower lid fullness even more pronounced, as a weak septum will not be able to hide the prominent lower lid fat pads and periorbital edema. Malar bags are a separate entity, usually caused by weakened and redundant orbicularis oculi muscle in its most inferior position, suspended and anchored by the orbicularis retaining (orbitomalar) ligament. This is corroborated by a report of festoon formation after injection of botulinum toxin type A into the infraorbital orbicularis oculi.¹⁴ Smokers may exhibit prominent malar bags, as the overlying skin with decreased elasticity and thinner dermis with less collagen content may show this fullness more clearly than in nonsmokers. It is unclear at this point whether the toxic effects of smoking cause direct damage to the orbicularis oculi itself or its retaining ligament. Although just short of statistical significance, we found a strong trend toward infraorbital hyperpigmentation in the smoker twins and in the twins with a longer smoking history.

In the lower third of the face, it is not a surprise to us that there are perioral wrinkles on the upper lip and the creases within the vermilion of the lower lip. The overall loss of skin elasticity can explain the presence of prominent nasolabial folds and jowls in the smoker, as these are both caused by the descent of facial tissues cephalad to them. A less taut skin envelope cannot counteract the effects of gravity. In addition, the overall thickness of the skin is greater in nonsmokers than in smokers, perhaps making the upper lip lines and nasolabial creases less discernible.

We acknowledge flaws to our study. Although we tried to the best of our ability to control for genetic and environmental factors of aging, we could not control for the effect of smoking on fat distribution. A large population-based study from the United Kingdom showed that smokers on average have a lower body mass index than nonsmokers and that smokers have a propensity for central fat deposition, with a higher waist-to-hip circumference ratio.¹⁵ Although in our study the body mass index of smokers and nonsmokers were well matched, the fat distribution of the smokers may have been central, causing a more deflated appearance of facial fat compartments and more accentuated wrinkles.

In addition, subtle movement in mimetic muscles can alter the appearance of facial wrinkles. We acknowledge that even a subtle difference in smile, such as in Figure 4, can lead to misleading depths of wrinkles (e.g., more pronounced crow's feet or nasolabial folds). In comparing individual sets of twins, surely there were times when the nonsmoker's individual features appeared older than those of the smoker. Therefore, a global assessment of facial aging was performed, and we found that the judges correctly identified the smoking twin as appearing older 57 percent of the time and the smoker of longer duration as appearing older 63.7 percent of the time. Although these values were statistically significant, this demonstrates that judging wrinkles by photography alone can be immensely difficult, as we were able to correctly identify the smoker/longer smoker between one-half and two-thirds of the time.

CONCLUSIONS

In our study of identical twins in which one twin smoked and the other was a nonsmoker, the smoking twin had worse scores for upper lid skin redundancy, lower lid bags, malar bags, upper lip vertical lines, lower lip vermilion wrinkles, nasolabial creases, and jowls. Among twins where both

were smokers with a difference in smoking history of 5 years or more, the twin who smoked longer had worse scores for lower lid bags, malar bags, and lower lip vermilion wrinkles. It is noteworthy that even among sets of twins where both are smokers, a difference in 5 years or more of smoking duration can cause visibly identifiable changes in facial aging.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

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