Factors Contributing to the Facial Aging of Identical Twins

Bahman Guyuron, M.D.
David J. Rowe, M.S., M.D.
Adam Bryce Weinfeld, M.D.
Yashar Eshraghi, M.D.
Amir Fathi, M.D.
Seree Iamphongsai, M.D.

Cleveland, Ohio; and Temple, Texas

Background: The purpose of this study was to identify the environmental factors that contribute to facial aging in identical twins.
Methods: During the Twins Day Festival in Twinsburg, Ohio, 186 pairs of identical twins completed a comprehensive questionnaire, and digital images were obtained. A panel reviewed the images independently and recorded the differences in the perceived twins' ages and their facial features. The perceived age differences were then correlated with multiple factors.
Results: Four-point higher body mass index was associated with an older appearance in twins younger than age 40 but resulted in a younger appearance after age 40 ($p = 0.0001$). Eight-point higher body mass index was associated with an older appearance in twins younger than age 55 but was associated with a younger appearance after age 55 ($p = 0.0001$). The longer the twins smoked, the older they appeared ($p < 0.0001$). Increased sun exposure was associated with an older appearance and accelerated with age ($p = 0.015$), as was a history of outdoor activities and lack of sunscreen use. Twins who used hormone replacement had a younger appearance ($p = 0.002$). Facial rhytids were more evident in twins with a history of skin cancer ($p = 0.05$) and in those who smoked ($p = 0.005$). Dark and patchy skin discoloration was less prevalent in twins with a higher body mass index ($p = 0.01$) and more common in twins with a history of smoking ($p = 0.005$) and those with sun exposure ($p = 0.005$). Hair quantity was better with a higher body mass index ($p = 0.01$) although worse with a history of skin cancer ($p = 0.005$) and better with the use of hormones ($p = 0.05$).
Conclusion: This study offers strong statistical evidence to support the role of some of the known factors that govern facial aging. (*Plast. Reconstr. Surg.* 123: 1321, 2009.)

Factors that contribute to facial senescence have been the subject of curiosity for centuries. Detecting these factors and educating the public can enormously reduce the amount of skin damage and the need for rejuvenation, and improve the outcome of the aesthetic goals during surgery. The Twins Day Festival attracts nearly 2000 to 3000 pairs of twins to Twinsburg, an area outside of Cleveland, Ohio. This large congregation of twins provides an unparalleled opportunity to conduct meaningful studies on a variety of medical conditions, including aging. Our research team used this opportunity and conducted a study to identify the environmental factors that influence facial aging in identical twins.

From the Department of Plastic Surgery, University Hospitals, Case Western Reserve University; and Division of Plastic Surgery, Texas A & M Health Science Center College of Medicine.
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METHODS

After obtaining institutional review board approval, the research team of the Department of Plastic Surgery at Case Western Reserve University set up a booth during the Twins Day Festival in 2006 and in 2007. In 2006, the team interviewed 98 pairs of identical twins, which included 18 pairs of men and 80 pairs of women between the ages of 18 and 76. In 2007, the team interviewed 88 pairs of identical twins. Each twin completed a separate comprehensive questionnaire. Digital images were obtained by the plastic surgery department photographer, with every effort being

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devoted to create consistency in lighting and sizing of the photographs. In addition, the images were standardized, and color- and size-matched at a later date as needed. Four judges reviewed the images independently and recorded the differences in the overall perceived twin ages and the facial features. The perceived age differences were then correlated with the multiple factors that could have been influential in aging (Tables 1 and 2). After data collection in 2006, additional features were added both to the questionnaire and the judge's reviewer sheet. Of the additional features that were added to the questionnaire, only the activities of the individuals and use of sunscreen were analyzed independently of the 2006 data. Otherwise, these new data were not independently analyzed during this study but may be used in future studies. Some of the questions used in 2006, however, were reworded for the 2007 questionnaire. The results were statistically analyzed using multiple regression. The *p* value was set at 0.05 or less. The multiple regression model was developed using a forward-selection, stepwise procedure with review. Interrater reliability was documented by the biostatistician. Furthermore, several twins analyzed in 2006 were also analyzed in 2007 to allow the biostatistician to also evaluate the interyear and interrater reliability.

Table 1. Analysis of Facial Features

- Overall perceived twin's age
- Skin youthfulness
- Coarse and fine rhytides
- Soft-tissue volume
- Hair quantity
- Hyperpigmentation
- Periorbital aging
- Brow ptosis
- Perioral changes
- Malar descent

Table 2. Possible Environmental Aging Factors

- Body mass index
- Duration of sun exposure
- History of skin cancer
- Duration of cigarette smoking
- Duration of hormone replacement
- History of radiation therapy
- History of chemotherapy
- Marital status
- Activities/hobbies

RESULTS

Interrater reliability in 2006 was found to be 1.0 years; in 2007 it was 2.0 years. When data from 2006 and 2007 were merged and reanalyzed, no bias between years was detected, and a new interrater reliability was found to be 1.7 years for all patient data. There were 13 pairs of twins available to establish the yearly repeatability of the respondents and raters. These interyear reliability data were used as an adjunct to create the total interrater reliability for this study. We found one inconsistency in one set of twins in which one twin changed the number of total years she was on oral contraceptives. Due to the discrepancy, the data for this twin pair were omitted for analysis of the effect of oral contraceptives on perceived age. In addition, the variance inflation factors for all in-

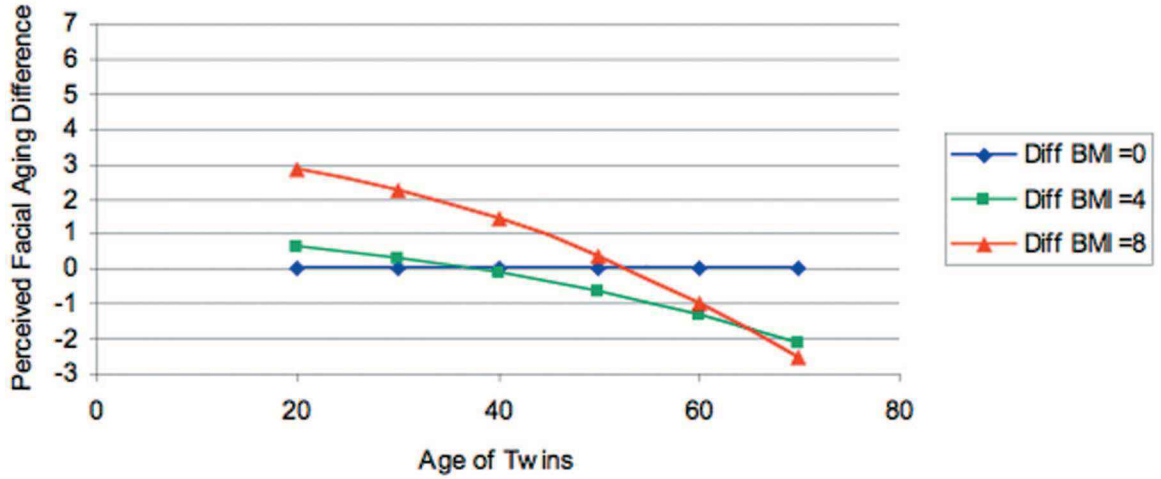

Fig. 1. Effect of body mass index difference on perceived facial aging difference. A four-point higher body mass index was associated with an older appearance in twins younger than age 40 but caused a younger appearance after age 40 ($p < 0.0001$). Conversely, an eight-point higher body mass index was associated with an older appearance in twins younger than age 55 but a younger appearance after 55 ($p < 0.0001$).

dependent variables in the model were less than 1.12, which indicates that colinearity among these variables was very small.

The Role of Body Mass Index

Body mass index was calculated, and the twins were divided into groups based on a four-point difference. A four-point higher body mass index was associated with an older appearance in the age group younger than 40, whereas it caused a younger appearance after age 40. An eight-point higher body mass index produced an older appearance in twins younger than age 55 but resulted in a younger appearance after age 55 (Figs. 1 and 2).

Fig. 2. Twins (natural age 58) with differences in body mass index. Twin A had a 14.7-point higher body mass index than twin B. No other differences were discerned from the questionnaire. Perceived age difference was 5.25 years.

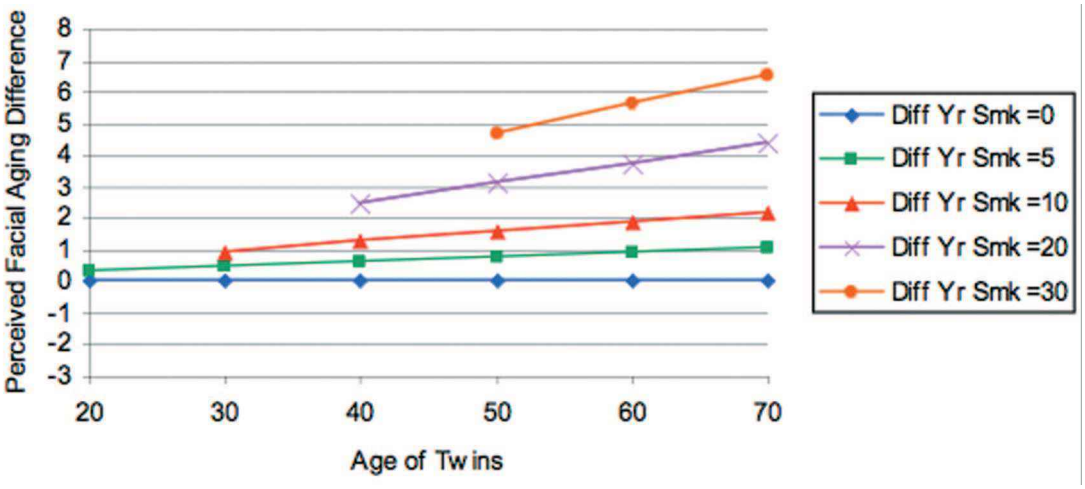

Fig. 3. Effect of years of smoking difference on perceived facial aging difference. The longer the twin smoked (beyond 5 years), the older she appeared ($p = 0.005$). Each 10 years of smoking difference led to a 2-year increase in perceived age.

Fig. 4. Twins (natural age 52) with difference in smoking history. Twin A (*left*) had a 20-year greater smoking history than twin B (*right*). Perceived age difference of the twins was 6.25 years.

Effects of Cigarette Smoking

The longer the twin smoked, the older she appeared ($p < 0.0001$). The minimum duration of smoking to result in perceived age change was 5 years. Each 10 years of smoking culminated to a 2½-year older appearance (Figs. 3 to 5).

Sun Exposure

Increased sun exposure was associated with an older appearance and accelerated with aging ($p = 0.015$) (Figs. 6 and 7). When evaluating the new 2007 questionnaire, those with outdoor hobbies such as golf and tennis had a perceived older ap-

Fig. 5. Twins (natural age 57) with difference in smoking history. Twin B (*right*) had a 40-year greater smoking history than twin A (*left*). Twin A had 2 years of hormone replacement therapy. The perceived age difference was 8.25 years.

pearance ($p < 0.05$). Also, skin protection using sunscreen led to a younger appearance ($p < 0.020$).

Hormone Replacement

Estrogen and progesterone replacements were associated with a younger perceived appearance ($p = 0.002$) (Figs. 8 and 9). As the age of the twin set increased, the effect of the hormone replacement therapy on age increased slightly. Also, larger differences of years of hormone therapy between the twins resulted in younger perceived age of the twin on hormone replacement therapy.

Fig. 6. Twins (natural age 61) with significant difference in sun exposure. Twin B (*right*) had approximately 10 hours per week greater sun exposure than twin A (*left*). Twin A had a body mass index 2.7 points higher than that of twin B. The perceived age difference was 11.25 years.

Alcohol Avoidance

The 2007 questionnaire also contained questions regarding alcohol avoidance. When compared with their twin, those who avoided alcohol were perceived to be significantly younger ($p < 0.0002$) (Fig. 10).

Marital Status

Women who had been divorced looked older than their married or single counterpart ($p < 0.004$). There were no differences found with increasing number of divorces. The twin who was divorced appeared about 1.7 years older than the

Fig. 7. Twins (natural age 69) with difference in sun exposure. Twin A (*left*) had 19 hours per week greater sun exposure than twin B (*right*). Twin A had received 4 more years of hormone replacement therapy. Perceived age difference was 3.375 years.

twin who was not divorced. The twin who was a widow or widower appeared about 2 years younger than the twin who was not.

Use of Antidepressants

The current or past usage of antidepressants was associated with a significantly older appearance when compared with the twin with no history of antidepressant use ($p < 0.05$).

Analysis of Features

All of the facial features analyzed by the raters were assessed independently as to their contribution to perceived aging. The presence of coarse rhytids, degree of malar descent, presence of glabellar "frown lines," orbital fissure orientation, presence of marionette lines, degree of nasolabial fold, and presence of excess submental fat were all statistically significant determinants in perceived age.

Rhytids were more visible in twins who had a history of skin cancer, which likely relates to sun exposure ($p = 0.005$). In addition, twins who smoked showed generalized and more specifically perioral rhytids ($p = 0.0005$). There was less skin discoloration in the twins with a high body mass index ($p = 0.01$) and more in those who smoked ($p = 0.0005$) and in those who had excessive sun exposure ($p = 0.0005$).

When hair quantity was taken into consideration, a higher body mass index and the use of hormones ($p = 0.005$) were associated with better hair quantity ($p = 0.01$), whereas twins who had a positive history of skin cancer had worse hair quantity ($p = 0.005$). The older-appearing twins had a higher eyebrow ($p = 0.05$); however, on further analysis, it was noted that invariably these patients who had a higher eyebrow had either eyelid ptosis or a significant blepharochalasis requiring frontalis compensation.

DISCUSSION

The perceived age of an individual is attributed to both genetics and environment, in varying degrees. Many deleterious environmental agents have been associated with facial aging; however, conclusive data have been elusory. Many investigations have shown that smoking and sun exposure are two main environmental determinants of perceived aging.[1–3] However, in these studies, despite their size, one cannot control for one of the most important contributors of aging: genetics.

Monozygotic twins, having identical genetic dispositions in terms of aging, offer an unmatched opportunity to assess the effects of the environmental factors on senescent changes. The current study utilized a large cohort of twins that congregate yearly to

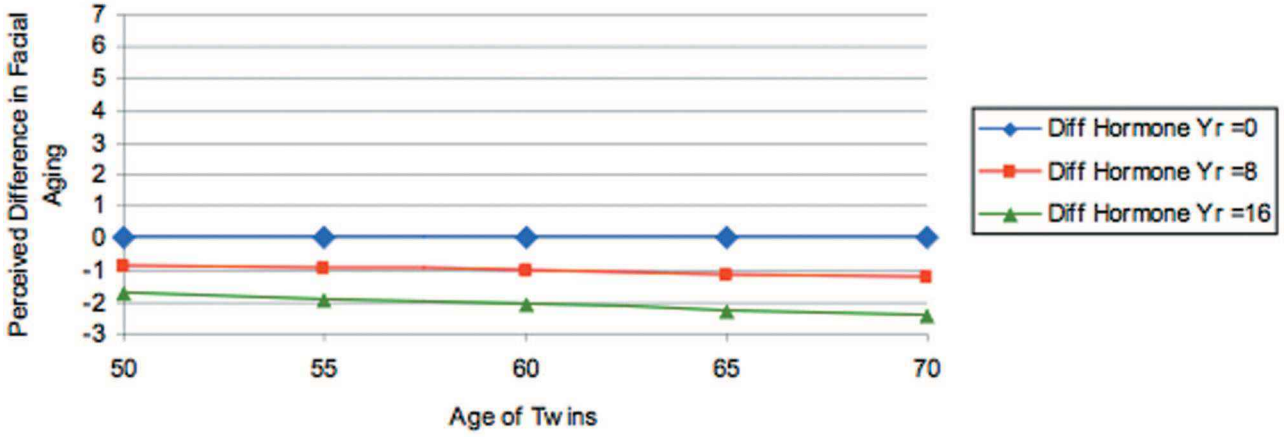

Fig. 8. Effect of years of hormone replacement therapy use difference versus perceived facial aging difference. Use of hormone replacement therapy was associated with a younger appearance ($p < 0.002$). The effect of hormone replacement was greater as the differences between years treated increased between twins.

celebrate their relatively unique human genetic characteristics. This study provides strong statistical evidence to support the role of some of the previously recognized, as well as several unrecognized, factors that may accelerate an aged appearance.

Several previously published reports have investigated twins and facial aging. Rexbye et al.[4] evaluated perceived age of 1826 pairs of 70^{+}-year-old twins (840 males and 986 females). As with the present study, they also found that significant determinants of aging include body mass index, smoking, and sun exposure. The current investigation differs in several important aspects. First, the Danish twins were greater than 70 years of age, giving a temporal "snapshot" of the influence of factors but not allowing the evaluation of the progression of change. Second, the photographs were nonstandardized, which leaves a possible margin of error due to lighting, background, and so on. Even several millimeters of obliquity can distort the size of one ear, eye, or the nose, possibly altering the evaluation of age. In the current study, professional photographers were used in standardized conditions. More importantly, Rexbye et al. estimated the twins' ages and used the difference between the ages to identify the factors, while in the current study the perceived age difference was estimated, reducing the potential for error. Antell and Taczanowski[5] collected data on 34 sets of twins and analyzed photographs versus multiple factors from a questionnaire. They report differences due to sun exposure and smoking, but no statistical analysis was performed. Furthermore, no description is given on how age was compared, the sex of the twins, or who analyzed the photographs. No information was provided on the quality or detail of the photographs. They, too, compared the twins' ages rather the perceived difference. Anecdotal statements were made about the weight, but the findings were different from those in this study.

Reversal of the role of body mass index in different age groups is fascinating. Ironically, excessive weight in twins who were younger than 40 years old caused their faces to appear older, perhaps due to the fact that it obscured certain facial structures better visible in the younger individuals. A four-point increase in body mass index beyond age 40 resulted in the twin appearing younger. Around age 55, an eight-point increase in body mass index produced a statistically significant rejuvenated appearance. Obviously, at this age, volume depletion is more substantial, requiring a higher body mass index to provide adequate change. This finding is mirrored in a large Danish study of elderly twins.[4] In this investigation, Rexbye et al. found that a lower body mass index in this set of female and male twins over the age of 70 resulted in a significantly increased perceived age. These data, in effect, support the role of volume replacement in facial rejuvenation. This is a cardinal finding and supports the rationale for selective volume augmentation in facial rejuvenation.

The two most investigated environmental causes of perceived aging are smoking and sun exposure. Smoking's effect on aging has been recognized for decades.[6] Smoking contributes to aging in a variety of ways. Individuals who smoke exhibit dense facial hyperpigmentation. Furthermore, dynamic lines develop around the perioral region. In addition, the elasticity of the facial skin is diminished and, perhaps more significantly, transient malar bags appear.[3] As with smoking, sun

Fig. 9. Twins (natural age 71) with difference in hormone replacement therapy. Twin B (*right*) had 22 more years of hormone replacement therapy than twin A (*left*). Twin B had a 1.2 lower body mass index. Perceived age difference was 7.25 years.

exposure leads to decreased elasticity of the skin. Further signs of photoaging include elastin clumping in the upper dermis, irregular epidermal cell maturation, collagen degeneration, and a thinning dermis. In the present study, both smoking and sun exposure were significant determinants in increasing one's perceived age. Furthermore, the participation in outdoor hobbies (presumably due to sun exposure) led to an increase in perceived age. These perceived age differences were present even

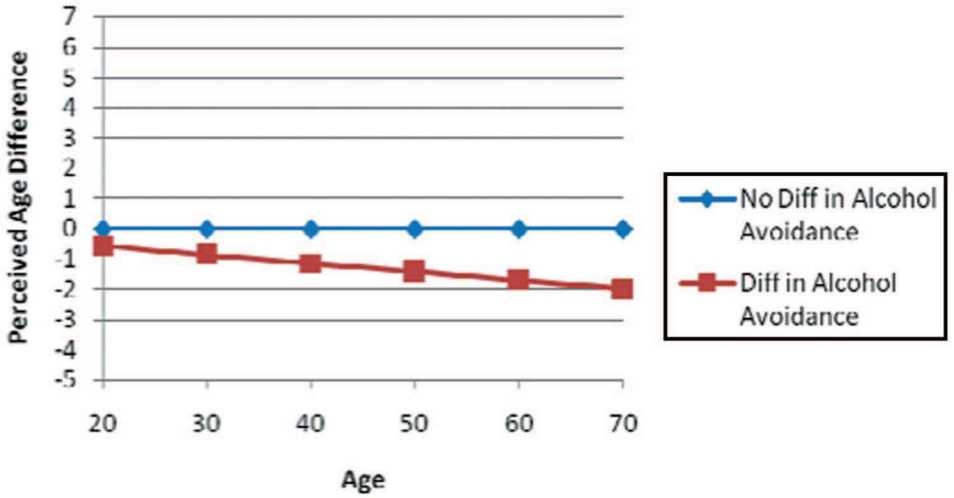

Fig. 10. Effect of alcohol avoidance on perceived facial age difference. Avoidance of alcohol was associated with a younger appearance ($p < 0.0002$).

at an early age, however, and became increasingly evident as the twin pair aged.

The role of hormones in aging is not as clearly defined. In females, estrogen contributes to the thickness and elasticity of the skin, although the mechanism is not clearly defined. Decrease of estrogen at menopause may lead to visible signs of facial aging, while hormone replacement therapy may potentially counteract these sequelae. Additionally, hormonal imbalance results in male pattern alopecia and a receding hairline.

The increased perceived age of female twins who used antidepressants was also seen. This is also corroborated by Rexbye et al., who found that depression was borderline statistically significant with facial aging.[4]

In the current study, twins who "avoided" alcohol were perceived to be younger than the twin who did not avoid alcohol. Alcohol consumption affects the human body in a myriad of ways far too diverse for the context of this article. The deleterious effects with respect to aging in the casual alcohol consumer are unknown. Chronic alcohol consumption may affect the hypothalamic-pituitary-adrenal axis and thus cortisol secretion.[7] The rates of type 2 diabetes mellitus, coronary heart disease, stroke, peripheral arterial disease, and overall cardiovascular disease may be increased in heavy drinkers but actually decreased in moderate consumers.[8] Data also suggest that red wine is a viable source of antioxidants that may augment oxidative protection mechanisms.[9] Our data collection was limited to the avoidance of alcohol mandated by our institutional review board. With this new correlation, it would be prudent to gain approval to add questions to our questionnaire pertaining to the amount of alcohol consumption and years of consumption.

The rise in the eyebrow as a consequence of aging is interesting because many plastic surgery authorities have claimed that this is an integral part of aging. With careful analysis of the photographs, however, it has become clear that this change is in reality a compensation for eyelid ptosis and redundant skin above the eyelashes rather than the real elevation of the eyebrow, which is inconceivable.

There were several limitations to this study. Despite the large number of twins that appear yearly, the difficulty in studying monozygotic twins is that many sets of twins develop nearly identical lifestyles. In fact, monozygotic twins are statistically significantly more similar in educational achievement, smoking, occupation, alcohol consumption, and exercise habits than their dizygotic counterparts.[10] Thus, a large number of twins are needed to discern environmental differences that may be a determinant in perceived facial aging. Another limitation is that the questionnaire was limited by the ability of the subject to recall particular life events, such as hours in the sun many years ago and the use of sunscreen and its sun protection factor value. This is acutely evident in the aforementioned comparison of one group of twins analyzed in 2006 and 2007, in which one of the twins changed the years of oral contraceptive use. In deference to these facts, multiple analyses were performed to ensure the relative accuracy of the data. Interrater reliability and year-to-year reliability factors were applied to the information to ensure that the differences seen were truly statis-

tically significant and were not merely the result of one spurious rater or an anomaly caused by an unusual twin pair.

CONCLUSIONS

Multiple environmental factors may contribute to facial aging. This analysis of monozygotic twins inherently allowed for the control of the genetic influences of aging. Our study provides further confirmation that aging and sun exposure have deleterious effects on the skin. Also, marital status, alcohol consumption, and use of antidepressants increased the perceived age of individuals. Increased body mass index in younger twins led to an older appearance, whereas as the twins increased in age, a higher body mass index led to a decrease in perceived age.

Bahman Guyuron, M.D.
Department of Plastic Surgery
University Hospitals
Case Western Reserve University
29017 Cedar Road
Lyndhurst, Ohio 44124
bguyuron@aol.com

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