Environmental Factors That Contribute to Upper Eyelid Ptosis: A Study of Identical Twins

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Abstract

Background: Current literature provides little information about the impact of environmental exposures on the severity of acquired blepharoptosis.

Objective: The authors assessed environmental factors that may contribute to eyelid ptosis in a population of identical twins.

Methods: Photographs of 286 sets of twins from a prospectively collected database from 2008 to 2010 were reviewed. The authors identified 96 sets of identical twins (192 individual persons) who had differing severity of ptosis. Digital photographs were analyzed, and the degree of ptosis was measured in each eye of every subject. The external factors that could potentially contribute to blepharoptosis were taken into consideration. The authors then assessed the correlations of 9 different environmental risk factors with ptosis. Generalized linear mixed model were constructed to determine the associations of ptosis measurements with environmental risk factors obtained from the subject survey database.

Results: The mean level of upper eyelid ptosis in the study population was 1.1 mm. The mean difference in ptosis between twins was 0.5 mm. Wearing contact lenses, either hard or soft, was significantly associated with ptosis. The mean ptosis measurement among twins who did not wear contact lenses was 1.0 mm; for those who wore soft contact lenses, the mean was 1.41 mm, and for those who wore hard contact lenses, the mean was 1.84 mm.

Conclusions: Acquired ptosis is not linked to body mass index, smoking behavior, sun exposure, alcohol use, work stress, or sleep. Wearing either hard or soft lenses was associated with an increased risk of ptosis. These influences are independent of genetic predisposition.

Level of Evidence: 3

Accepted for publication October 10, 2014.

Periorbital rejuvenation has long been a focus of aesthetic surgery. Common problems of the aging eye includes brow ptosis, excess upper eyelid skin, fat protrusion, and eyelid ptosis.\(^1\,^2\) When an individual is in a resting straight gaze, the normal anatomic position of the upper eyelid margin should be 1 mm below the upper edge of the limbus. When the eyelid falls below this point, it is considered ptotic.\(^1\) Eyelid ptosis creates a tired and aged appearance. When ptosis is severe, it can create a mechanical obstruction to the field of vision. Treatment for most cases of ptosis is surgical, but it is important to establish the cause before undertaking any intervention.

Ptosis has myriad listed causes that must be considered before any operative correction. These causes can be divided into 6 different subtypes: congenital (levator maldevelopment), myogenic, neurogenic, aponeurotic, mechanical, and pseudoptotic.\(^3\) Myogenic ptosis is the result of diseases such as myasthenia gravis and chronic progressive ophthalmoplegia. Causes of neurogenic ptosis include cerebral vascular accidents and multiple sclerosis. Mechanical ptosis can be related to tumors, cysts, and enlarged lacrimal glands. Severe facial trauma to the orbit or periorcular tissues can also lead to ptosis.\(^4\,^5\) Pseudoptosis can be caused by enophthalmos secondary to facial trauma or severe dermatochalasia that overlaps the upper eyelid margin. Elimination of the

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above causes of acquired ptosis or pseudoptosis leads one to the diagnosis of involutional or aponeurotic ptosis. Aponeurotic ptosis is presumed to result from the disinsertion or thinning of the levator muscle aponeurosis that has been considered part of the natural aging process. Microtraumatic influences, such as wearing contact lenses, eye rubbing, and having cataract surgery, have all been implicated as potential causes of aponeurotic ptosis, although no study has accounted for the influence of genetic predisposition. Environmental factors, such as sun exposure, alcohol consumption, and smoking behavior, have been shown to affect signs of facial aging. Currently, the literature is devoid of information about the influence of these environmental factors on ptosis. We designed a study to assess the influence of environmental factors on ptosis by analyzing and reviewing the histories of identical twins with varying severity of blepharoptosis.

**METHODS**

We obtained institutional review board approval from University Hospitals, Case Medical Center, Cleveland, Ohio, to evaluate which environmental factors affect signs of aging in twins in a retrospective cohort study. We analyzed photographs and social/medical history questionnaires from a database that contained information collected at the annual Twins Days Festival in Twinsburg, Ohio, from 2008 to 2010. The questionnaires provided data on contact lens use, alcohol consumption, sun exposure, smoking behavior, work stress rating, and sleep habits (Supplementary Material). A full series of facial photographs was taken of each subject at the time of the survey. Photographs were taken with a Nikon SRL camera (Tokyo, Japan) using a Nikon ring flash from an approximate distance of 4 feet using a 16 f-stop, 1/60 shutter speed, ISO 100 with manual focus. The camera was calibrated and white balanced on the spot to suit the lighting conditions that day. Twin sets had photographs taken only minutes apart and were exposed to the same relative environmental lighting factors. All subjects provided informed consent.

Photographs of 286 twin sets were screened by 2 independent reviewers to identify twins with different levels of ptosis noticeable on frontal view. These frontal-view photographs were compared with photographs of the subjects smiling to evaluate change in brow position and with lateral photographs to evaluate overall globe position. Twins sets in which one twin had a significantly different brow position when smiling compared with resting were excluded to eliminate the impact of brow compensation on the ptosis measurement. Twins with evidence of a significant positive vector or enophthalmos were excluded to eliminate the effect that globe position may have on eyelid position. Additionally, subjects with a history of congenital ptosis, neurogenic disorders, ocular disorders, or past ocular surgery were excluded.

Photographs of patients who met the above criteria underwent detailed evaluation. The typical limbus is 11 mm in diameter. In a patient without ptosis, the upper eyelid will overlap the upper edge of the limbus by 1 mm. Ptosis was measured by first assessing the digital photograph pixel count from the midpupil to the inferior edge of the limbus. This pixel count was set to 5.5 mm. If the lower limbus was not visible, the contralateral eye was used for both eyes. A second measurement was taken from the midpupil to the upper eyelid margin. The distance was converted to millimeters based on a ratio comparison to the previously defined midpupil-to-lower limbus distance. Eyes with distances less than 4.5 mm were defined as ptotic, with the severity measured in millimeters (Figure 1). The mean of both measurements was used for statistical analysis.

Statistical analyses were performed using Microsoft Excel 2010 (Microsoft, Redmond, WA). Environmental factors
were correlated with trends in ptosis using a univariate
generalized linear mixed model in SAS, version 9.3 (SAS
Institute, Inc., Cary, NC). Significance was defined at a
level of \( P < .05 \).

**RESULTS**

We identified a total of 96 twin sets (192 subjects) who met
the inclusion criteria and had appreciably different levels of
ptosis (Figure 2). The subjects included 44 men and 148
women who had a mean age of 48.5 years (range, 18-82
years). The mean body mass index (weight in kilograms
divided by height in meters squared) was 26.4 (range,
16.4-52.7). There were 70 patients who reported a history
of smoking (mean, 18.7 pack-years; range, 1-66 pack-
years). Ninety-nine patients who reported drinking
alcohol, with a mean consumption of 2.4 drinks per week.
The mean calculated sun score was 117.9.

The mean ptosis measurement was 1.1 mm. The
distribution of ptosis severity demonstrated 89 subjects
with 0-1 mm of ptosis, 73 subjects with 1-2 mm of ptosis,
and 27 subjects with 2-3 mm of ptosis. Three subjects had
greater than 3 mm of ptosis. The mean differential ptosis
between the more and less ptotic twin was 0.5 mm. There
were 59 sets of twins that had difference in ptosis of <1
mm, 35 sets who had a difference of 1-2 mm, and 2 sets
who had difference of >2 mm (Table 1).

We assessed the correlation of ptosis with 9 different en-
vironmental risk factors. The factors that showed no statis-
tical association with increased ptosis were body mass
index, hours of sleep per night, work stress, smoking, and
alcohol consumption. Wearing either hard or soft contact
lenses was significantly associated with ptosis (Table 2).
Hard contact use was associated with more ptosis than was
soft contact use (Figure 3).

Of the 192 subjects in the study, 47 reported wearing
contact lenses. Thirteen of these subjects had twins who
did not wear contacts. Further analysis revealed the mean
severity of ptosis in subjects who did not wear contact
lenses was 1.0 mm. Those who wore soft contact lenses

![Figure 2](https://example.com/figure2.png)

**Figure 2.** These 39-year-old female identical twins had differing levels of ptosis. These patients were visually identified from a
twins database and had individual ptosis measured in each eye. (A) This twin did not wear contact lenses. (B) This twin did wear
contact lenses.
had a mean ptosis measurement of 1.41 mm, and those who wore hard contact lenses had a mean measurement of 1.84 mm (Table 3).

**DISCUSSION**

Blepharoptosis, which can result in stigma as people age, can cause both functional and cosmetic changes to the eyes. Ptosis is often recognized in patients who are seeking aesthetic blepharoplasty, and it is important to correct the problem during that procedure; otherwise, preoperative ptosis will be more apparent postoperatively. Surgical interventions for the treatment of ptosis have been well described and include levator suspension and the Fasanella-Servat, the Putterman, and the modified Putterman procedures.11-13 Ptosis can stem from a variety of causes, and before surgical intervention it is important to rule out all systemic or medical causes of acquired ptosis. Elimination of all other causes during a work-up for ptosis leaves the surgeon with the diagnosis of aponeurotic ptosis. Unless there is a specific, identifiable traumatic event, the ptosis is attributed to attenuation of the levator aponeurosis. Attenuation of the levator has been considered part of the natural aging process, although in multiple studies, researchers found ptosis in younger individuals that was not attributed to any commonly identifiable cause or traumatic event.6,7,14 We eliminated subjects who had undergone previous eye or eyelid surgery because these types of surgeries could have a significant impact on ptosis and would introduce too much variability into the present study. To our knowledge, this was the first study to broadly evaluate environmental factors known to impact facial aging specifically to determine an influence on ptosis.9,10,15,16

Ptosis can be visualized and measured on an anterior to posterior view photograph taken with subjects in repose, but care must be taken to eliminate other influencing factors. All subjects with potential medical causes, neurological causes, and previous ocular trauma or surgery were eliminated from the study. Additionally, careful analysis of multiple photographs was used to identify and exclude subjects with evidence of enophthalmos, significant dermatochalasia obstructing the upper eyelid, eyebrow ptosis, or ptosis compensation with activation of the frontalis. This allowed us to account for most factors that could potentially influence ptosis in our evaluation. Excluding all other causes of ptosis and accurately assessing the severity of ptosis were of paramount importance to the analysis.

This study is the first to demonstrate that sleep duration, sun exposure, alcohol consumption, work stress, and smoking do not significantly impact acquired ptosis after controlling for genetic influence. One could hypothesize that lack of sleep and irritation of the eyes that leads to rubbing could result in stretching of the levators of the upper eyelid. This would have the potential to induce ptosis over time. However, in the present study, we found no significant link between these factors and eyelid ptosis.

Contact lens wear has previously been implicated in acquired ptosis. In 1891, Epstein and Putterman showed evidence of ptosis in a case series of 5 contact lens wearers. Kersten et al14 and van den Bosch and Lemi17 found rates of eyelid ptosis in hard contact lens wearers that ranged from 23% to 43%. In a study of 46 subjects and an age-matched control group, van den Bosch and Lemi found a mean of 0.5 mm more ptosis with contact lens wearers. Bleyen
et al\textsuperscript{18} and Reddy et al\textsuperscript{19} have also shown an association between ptosis and wearing soft contact lenses. Very recently, Kitazawa\textsuperscript{20} published a case-control study in a Japanese population and found a higher prevalence of contact use among patients with ptosis. The present study further validates the findings of those authors with an objective reproducible method that establishes the significant impact of contact lens use on ptosis.

The exact mechanism of contact lens-induced ptosis has not been fully elucidated. It is theorized that pulling of the upper eyelid for contact placement and removal may lead to chronic microtrauma, laxity, and discontinuity of the levator. Watanbe et al\textsuperscript{21} studied biopsies from 30 subjects with ptosis, 15 of whom wore contact lenses and 15 of whom did not. They found that wearing contact lenses use associated with fibrosis within Mueller’s muscle, whereas age-related ptosis showed discontinuity within the muscle. They postulated that fibrosis within Mueller’s muscle leads to decreased contractility.

This study has several identifiable advantages over the previously reported literature. Directly comparing identical twins creates the ideal case-control comparison. Our study with 192 subjects, 47 of whom wore contact lenses, represents one of the largest population-based studies of acquired eyelid ptosis. Although multiple studies have specifically focused on the impact of wearing contact lenses, the present study was designed with a broader focus in an attempt to determine whether any other environmental factors contribute to ptosis. Additionally, in

Table 3. Mean Ptosis Measurements in Subjects by Type of Contact Lens Worn

<table>
<thead>
<tr>
<th>Type of Contact Lens</th>
<th>Mean Ptosis Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1.00 mm</td>
</tr>
<tr>
<td>Soft</td>
<td>1.41 mm</td>
</tr>
<tr>
<td>Hard</td>
<td>1.84 mm</td>
</tr>
</tbody>
</table>

Figure 3. These 65-year-old female identical twins had differing levels of ptosis related to wearing contact lenses. (A) This subject wore soft contact lenses and had less ptosis than her twin. (B) This subject wore hard contact lenses and had more severe ptosis than her twin.
most studies, patients are categorized as either having or not having ptosis. We measured the amount of ptosis and determined the associations of those measurements with various environmental factors. Not all acquired ptosis between twins can be explained by contact lens use. In our population, the mean ptosis measurement was 1.1 mm. Approximately 15.2% of subjects had a measurement > 2 mm. There are likely other unidentified factors that play a role in the development of ptosis. Although we tested 9 different environmental factors that were hypothesized to be involved, the present study is not comprehensive. The mean age of our population was 48.5 years, and it is possible that environmental factors, such as sun exposure, smoking, lack of sleep, and alcohol consumption, might take several years to cause significant changes in ptosis severity, which would therefore be apparent in older subjects. Murchison et al commented that different ethnicities have variability in the normative margin reflex distance (MRD1). In their study population, white subjects had a mean of MRD1 of 5.1 mm, whereas black subjects had a mean MRD1 of 4.5 mm. We did not adjust for ethnicity; however, the difference in ptosis measurements between twins would not have changed regardless of the normative values used to measure absolute ptosis. Most of our subjects were white population, and using above normative values would have increased the overall amount of ptosis reported.

In the senior author’s practice, many patients with detectable ptosis have had no identifiable cause other than wearing contact lenses. Acquired ptosis of this kind is highly responsive to surgical treatment, and the Guyuron and Davies have shown the value of the modified Putterman technique.

The primary disadvantage to the present study is the reliance on data from photographs. Life-sized photos were not taken, but a detailed analysis process allowed us to make a ratio-based comparison and calculate ptosis severity. In the repose position, the body will do many things to compensate for ptosis, including activating the frontalis and raising the eyebrows. Hering’s law of equal innervation may also mask the presence and severity of ptosis. A person with unilateral ptosis that is visible in repose may have suffered from bilateral ptosis that was masked by the increased work of the eyelid elevators. Standardized photographs have been used to evaluate and measure ptosis in several studies.

Lastly, more information about the length of contact lens use, reason for contact lens use, and specific visual correction in each eye might have provided more insight into the characterization of contact lens–induced ptosis.

CONCLUSIONS

Wearing either hard or soft contact lenses was the only environmental factor that we found to be associated with acquired blepharoptosis. No other factors were identified as having a significant impact. The actual mechanism of contact lens–induced ptosis is still poorly understood, although recurrent traction on the eyelid during placement and removal likely leads to changes in the levator aponeurosis and Mueller’s muscle. This type of ptosis is amenable to correction using the modified Putterman technique.

Supplementary Material

This article contains supplementary material located online at www.aestheticsurgeryjournal.com.

Disclosures

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Funding

The authors received no financial support for the research, authorship, and publication of this article.

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