



The role of ethnicity versus environment in tear film stability: A pilot study

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ABSTRACT

Purpose: Existing literatures suggest a difference in tear film stability between Caucasian and Asian ethnic groups. However, such a finding was compounded by the fact that the comparison was done on subjects living in different environments. Therefore, it is not clear whether such difference is due to ethnicity, environment, or both. The aim of this study is to clarify the roles of these two factors.

Methods: A total of 88 asymptomatic subjects participated in this present study. For each subject, the tear film break-up time (TBUT), non-invasive TBUT (NITBUT) and tear meniscus height (TMH) were measured. To isolate the effect of ethnicity, the results of 12 American Asian young adults were compared against the results of 23 Caucasian adults. Both groups were recruited from Nova Southeastern University. To elucidate the effect of environment, the results from the same 12 American Asians were compared to that of the 53 Asian young adults recruited from the Tianjin Vocational Institute, China (Tianjin Asian).

Results: The tear film stability did not show significant difference among American Asian subjects and Caucasian subjects in TBUT (10.49 ± 2.86 s vs. 11.06 ± 2.79 s, $p = 0.57$), NITBUT (11.19 ± 4.89 s vs. 11.14 ± 6.20 s, $p = 0.98$), and TMH (0.21 ± 0.08 mm vs. 0.22 ± 0.05 mm, $p = 0.59$). However, the tear film stability was significantly better in the American Asian group than the Tianjin Asian group in TBUT (10.49 ± 2.86 s vs. 7.60 ± 3.26 s, $p = 0.01$), NITBUT (11.19 ± 4.89 s vs. 8.03 ± 3.56 s, $p = 0.01$), and TMH (0.21 ± 0.08 mm vs. 0.14 ± 0.03 mm, $p < 0.01$).

Conclusions: The previously reported difference in Caucasian and Asian populations might be due to the fact that the studied subjects have different living environments.

1. Introduction

The tear film is the first line of defense in keeping the ocular surface wet. It is essential for maintaining the health of the ocular surface and ensuring a smooth refracting surface. Therefore, its stability is routinely assessed in the diagnosis of dry eye disease. Reduced quantity and stability of the tear film not only affects visual quality [1], but also reduces a patient's prognosis of being able to wear contact lenses successfully.

The most common evaluation of tear film stability is the tear break-up time (TBUT), the amount of time that elapses the moment a tear film first breaks up after a complete blink [2,3]. To minimize the influence of fluorescein on tear film stability, non-invasive tear break-up time (NITBUT) have been adopted more in recent years. Tear meniscus height (TMH) is an index used to evaluate the tear quantity [4], as 75–90% of the tear volume is stored in the tear meniscus [5].

The ethnic differences in tear film stability have been long studied.

It has been reported that the breakup times of non-Caucasians is substantially shorter than those of Caucasians [6,7]. Non-Asians have been reported to have more stable tear films compared with Asians [8,9]. In particular, Cho and Brown reported that the mean TBUT value of Caucasians is greater than the mean TBUT value of Hong Kong Chinese [10]. These evidences lead to the suggestion that being of Asian descent is a significant risk factor for dry eye disease, with an odds ratio of 1.5–2.2, once gender and age are controlled for [11]. However, Cho et al. reported no significant difference in the median TBUT and NITBUT values between Chinese and Caucasian subjects [12]. Therefore, whether ethnicity can explain the difference in tear film is, at best, inconclusive.

It is well known that tear film stability is influenced by environmental conditions, such as temperature, humidity, wind, altitude, air pollution, including smoke and other atmospheric irritants, and even air currents [13–15]. Noticeably, adverse conditions, such as extreme low humidity, can severely disrupt the tear film stability [15,9]. For

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instance, the prevalence of dry eye in people living in desert and plateau regions is much higher than that of people living in cities with mild climates [16]. In these previous studies, the compounding effect of environment could not be excluded.

Therefore, the aim of this study is to elucidate the effect of ethnicity and environment. In order to isolate the effect of ethnicity, the results from Asians and Caucasians living in the same environment were compared. Similarly, to extract the effect of environment, the results from American Asians were compared to the results obtained from Tianjin Asians.

2. Methods

2.1. Subjects

53 young adults (12 male and 41 female, aged 21.4 ± 0.86 years) were recruited from Tianjin Vocational Institute (Tianjin, China), while 23 Caucasian subjects (12 male and 11 female, aged 25.4 ± 3.84 years) and 12 Asian subjects (4 male and 8 female, aged 23.8 ± 3.78 years) were recruited from Nova Southeastern University (Fort Lauderdale, Florida). Subjects were excluded if they were using eye-drops or were suffering from systemic conditions or seasonal allergies that could alter the quality or quantity of their tear film. Any symptoms of dry eye or contact lens wear history also led to exclusion. Subjects were requested not to wear eye make-up before or during the data collection. This study adhered to the tenets of the Declaration of Helsinki. Ethics clearance for the use of human subjects was obtained through the Institutional Review Board and received approval from both Nova Southeastern University and Tianjin Vocational Institute. Written informed consent was obtained from all subjects before their participation in this study.

2.2. Procedures

The examinations were performed in the following sequence: NITBUT, TMH, and TBUT. All measurements were conducted by the same examiner from 10 to 11 a.m. local time, when tear stability is reported to be relatively high [17]. The examination room was dimly lit. Room temperature and humidity were monitored and controlled at 21.0 ± 0.6 and $40 \pm 2\%$. The lab was air conditioned with doors and windows shut. Only the data from the right eye were included into analysis. All measurements were repeated three times for each subject, and the average was noted. One reading was obtained from each instrument at a time with a 5-minute interval between measurements to ensure that normal tear function was restored. 53 young adults from Tianjin Vocational Institute were examined at Tianjin Vocational Institute from June to August. The 23 Caucasian subjects and 12 Asian subjects that were recruited from Nova Southeastern University were examined at Nova Southeastern University from April to May. The models of the instruments used in the two places are the same.

2.2.1. NITBUT

NITBUT was performed using a Keratometer (BL-8001). As each subject was instructed to refrain from blinking and to fixate on a central light source, rings from a lighted cone were projected onto the corneal surface. The native software captures images of the reflected rings, starting from the last blink. NITBUT was measured as the time from the last complete blink to the first appearance of a distortion of the lines. Subjects were instructed to blink when any discomfort was felt to minimize reflex tearing.

2.2.2. TMH

The height and quality of the lower tear prism (lacrimal lake) were evaluated during a slit-lamp examination. TMH was defined as the line distance from the fluid surface of the inferior cornea-meniscus junction to the lower eyelid-meniscus junction. The line distance between the

two points was decided manually using a slit-lamp (Topcon, SL-3 G). The slit lamp's spot light with a diameter of 0.5 mm was used. The width of the TMH was compared against the diameter of the spot. When the meniscus is so thin that it appears as a fine line, it can be said to be a significantly insufficient tear meniscus.

2.2.3. TBUT

A wide beam (full aperture) was used so that the entire cornea was illuminated and viewed with $10\times$ magnification. Fluorescein (Ful-Glo Fluorescein strip) was applied to the upper bulbar conjunctiva of the right eye. The subject was then asked to blink a few times after fluorescein application to distribute the fluorescein. The subject was asked to look directly ahead and to refrain from blinking until told to do so. The conjunctival staining and corneal staining were examined using a slit-lamp microscope with a cobalt blue filter. TBUT was considered to be the time from the blink to the first appearance of black spots.

2.3. Statistical analysis

Statistical analysis was performed using SPSS version 20 (IBM Corporation, Armonk, NY, USA). Data were summarized with mean \pm standard deviation and medians. After confirming the data normality with Shapiro-Wilk test, the discrepancies between any two groups were determined with a two-samples t-test. A *P* value of 0.05 indicated significant difference.

3. Results

3.1. The effect of ethnicity

The tear film stability did not show significant difference among American Asian subjects and Caucasian subjects in TBUT (10.49 ± 2.86 s vs. 11.06 ± 2.79 s, $p = 0.57$, Fig. 1A), NITBUT (11.19 ± 4.89 s vs. 11.14 ± 6.20 s, $p = 0.98$, Fig. 1B), and TMH (0.21 ± 0.08 mm vs. 0.22 ± 0.05 mm, $p = 0.59$, Fig. 1C).

3.2. The effect of environment

The tear film stability was significantly better in American Asians than Tianjin Asians in TBUT (10.49 ± 2.86 s vs. 7.60 ± 3.26 s, $p = 0.01$, Fig. 2A), NITBUT (11.19 ± 4.89 s vs. 8.03 ± 3.56 s, $p = 0.01$, Fig. 2B), and TMH (0.21 ± 0.08 mm vs. 0.14 ± 0.03 mm, $p < 0.01$, Fig. 2C).

Note, the mean values of TBUT and NITBUT in Tianjin Asians were lower than 10 s, which is usually considered as the threshold for normal values. In fact, 83.0% of the Tianjin subjects and 56.9% of the US students have NITBUT shorter than 10 s (Fig. 3A). Additionally, for TBUT, 81.1% of the Tianjin subjects and 60.3% of the US students had values of shorter than 10 s (Fig. 3B). No conjunctival staining and corneal staining were observed in all subjects.

4. Discussion

This present study found that the tear film stabilities were not significantly different between Asian and Caucasians living in the same environment in America. However, the Asians living in different environments, Florida versus Tianjin, showed significant difference in tear film stability. Over 80% of the subjects in Tianjin showed TBUT and NITBUT values lower than 10 s, which is often considered as the normal cutoff.

4.1. Effects of ethnicity

Many internal factors have been associated with tear film stability, including sex, age, medications, ethnicity. Earlier studies suggesting the difference between Asian and Caucasian populations were from an

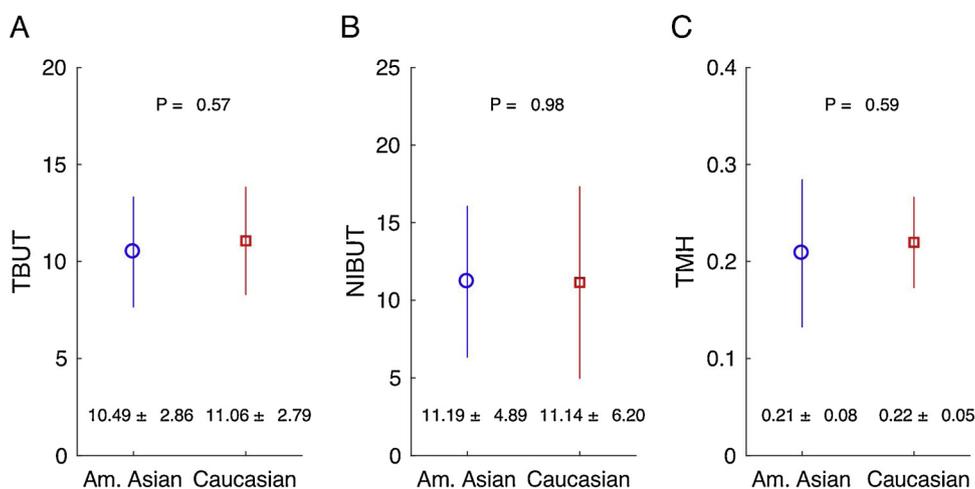


Fig. 1. The effect of ethnicity (American Asians versus Caucasians) A) TBUT; B) NITBUT; C) TMH.

epidemiology survey. The prevalence of dry eye disease, as reported previously, is 33.7% in Taiwan [18], 33% in Japan [19], and 27.5% in Indonesia [20]. These percentages are higher than those found in studies of Caucasians, such as the percentages found during the Salisbury Eye Evaluation Study [21] (14.6%) and the Beaver Dam Eye Study [22] (14.4%). Consequently, more studies were conducted on healthy subjects. Some studies suggest that healthy Asian subjects have an 11% to 24% shorter tear film breakup time than non-Asians [8]. Cho et al. reported that the mean TBUT value of Hong Kong Chinese is lower than the mean TBUT value of Caucasians [23]. More studies were performed to explain potential anatomical and physiological reasons for this difference. For example, a study from the University of California, Berkeley Clinical Research Center, found that a larger palpebral aperture size was significantly associated with a more stable tear film, and the Asian palpebral aperture size is smaller than that of non-Asians [24]. It hypothesized that the tear lipid layer is not able to efficiently perform its usual expansion and compression during a blink in an eye with a small palpebral aperture size, resulting in a less stable tear film. As for the composition of human tear lipids [25,26], the Chinese have less polar lipids according to the results reported by Australian researchers [26]. Therefore, it was found that healthy Asian subjects have a 11% to 24% shorter tear film breakup time than non-Asians [8]. The results from this present study disagrees with those previous studies. After controlling the effects of environment, the American Asians and Caucasians did not show any significant difference in TBUT, NITBUT, and TMH. However, differences in measurement instruments may also

contribute to this disparity.

4.2. Effects of environment

The subjects of this experiment were examined locally, and the controlled inspection environment was consistent from June to August in Tianjin and April to May in Fort Lauderdale. In this study, efforts were taken to keep the indoor environment consistent to exclude the influence of indoor environment on the eye condition. Room temperature and humidity were monitored and controlled at $21.0 \pm 0.6^\circ$ and $40 \pm 2\%$, and the measurement was conducted after a 10-minute rest in the room. However, tear film stability can be influenced by external environmental conditions, such as temperature, humidity, air pollution, including smoke and other atmospheric irritants, air currents, and even altitude [27–29]. Several environmental differences exist between Tianjin and Fort Lauderdale. First, Tianjin is located at the north part of China with a latitude similar to Boston, while Fort Lauderdale is located at the south part of Florida. Therefore, ambient temperature is an external environmental factor that could affect the tear film. Indeed, it has been reported that a significant difference in tear stability and production was found in normal subjects living in places characterized by a warm climate compared with those living in colder places [30]. Tear film lipid layer is affected significantly at low temperatures [27]. Low humidity in Tianjin and high humidity in Fort Lauderdale could be another contributing factor [31]. The evaporation rate of the tear film increased sharply during exposure to the dry

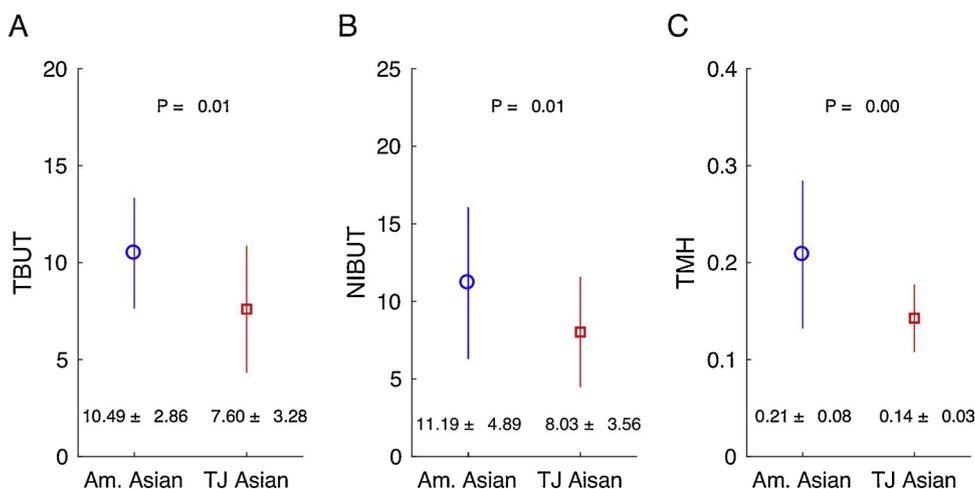


Fig. 2. The effect of environment (American Asians versus Tianjin Asians) A) TBUT; B) NITBUT; C) TMH.

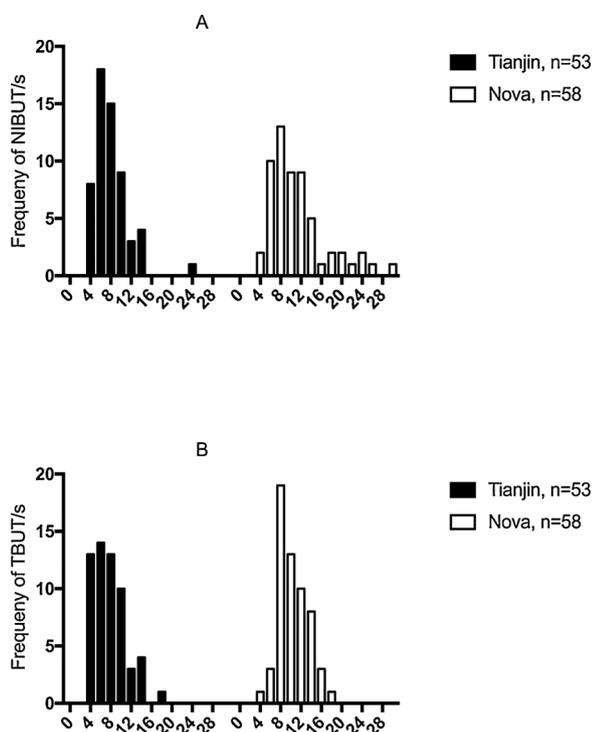


Fig. 3. The distributions of Tianjin and Nova students A) NITBUT; B) TBUT.

environment and tear stability was significantly lower. Second, in recent years, another important factor to consider is the smog in the air in northern Chinese cities. Previous studies have shown that outdoor air pollution reduced tear film stability among workers in an area where an accidental explosion had occurred [32]. Tear film abnormalities are related to chronic exposure to outdoor air pollution [33]. Third, the cities in north China often experience strong winds during the winter, while south Florida rarely experience such conditions. Wyon et al. reported that exposure to high air velocity caused a significant decrease in tear stability in healthy eyes, but that exposure to moderate air velocity for the same time period had no effect on TBUT [34]. This is also supported by the evidence that a higher prevalence of dry eye among Hans versus Uyghurs in Kashi, an area that harbors a windy environment.

4.3. Diagnosis standards

In this study, over 80% asymptomatic Chinese and 50% of US subjects had TBUT and NITBUT values below the typical 10 s threshold for dry eye diagnosis. Of particular interest is that the Chinese students appeared to have a much lower mean value and narrower value range for TMH. These results indicated that the optimum threshold for dry-eye diagnosis should be somewhat lower than 10 s, especially for Asian patients. However, many Asians with TBUT values between approximately 7 and 10 s do not have dry eye symptoms. Hence, a better standard for quantifying tear stability needs to be considered in the future.

4.4. Conclusion

The findings from this study suggested that the reported difference in Caucasian and Asian populations might not be ethnic in nature, rather it is more likely due to differences in environment. However, more investigation is warranted due to the limited sample size of this pilot study.

Competing interest statement

Authors have no competing interest to reveal.

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