Original Article

Excessive Blinking in Children and Its Association with Dry Eyes and Visual Display Terminal: A 200 Case-Control Study

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Objective: To identify the cause of excessive blinking in apparently healthy children, and to evaluate its association with visual activities including visual display terminal use.

Material and Methods: The present study was a descriptive cross-sectional case-control study included 200 children aged 6 to 14 years with chief complaints of excessive blinking (study group) and routine eye check-up visits (control group). All participants underwent a complete eye examination including blink rate and tear break-up time measurement. Parents were asked to answer questionnaires regarding tic disorder and duration of visual activities.

Results: One hundred children in the study group (mean age 7.9±2.0 years) and 100 children in the control group (mean age 9.5±2.3 years) were enrolled. Participants in the study group were predominantly male (77% versus 44%) and had a higher blink rate (30 versus 9 blinks/minute) compared to the control group. In the study group, there was a significantly higher percentage of participants diagnosed with dry eyes (73% versus 6%, p<0.001), allergic conjunctivitis (41% versus 0%, p<0.001) and tic disorder (19% versus 9%, p 0.042) than in the control group. One third of the participants in the study group had mixed diagnoses of dry eyes and allergic conjunctivitis. There was no significant difference in the duration of visual activities including visual display terminal use between groups.

Conclusion: Excessive blinking occurred more commonly in boys. The most common associated disorders with excessive blinking in children were dry eyes, followed by allergic conjunctivitis and tic disorder. There was no association between excessive blinking in children and duration of visual display terminal use.

Keywords: Blinking; Excessive blinking; Dry eyes; Visual display terminal

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Excessive blinking in children is one of the most common chief complaints in pediatric ophthalmology department. It affects the children's life and is a cause for parents' concern. Moreover, the excessive blinking could be the first sign of underlying ophthalmic diseases, behavioral disorders and neurological diseases.

Previous studies reported various causes of excessive blinking in children[1-4]. Central nervous system disorders, habit tics, uncorrected refractive error, allergic conjunctivitis, psychiatric disorders, stress, and intermittent exotropia or exophoria are the main diagnoses in children with excessive blinking[1-3]. Since those previous studies evaluated only symptomatic children, it was not clear whether those conditions were truly the causes of or just associated with excessive blinking.

Blink rate normally increases with age[5,6]. Spontaneous blink rate in children was reported to be 7 to 19 blinks/minute[5,7,8]. Different activities can affect the blink rate[8]. The visual display terminal use has been reported to affect children's eyes because it

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Table 1. Duration of visual tasks and tic disorder screening questionnaire

Duration of visual tasks		
Visual tasks	Duration per day out of school time (hours)	
	Weekdays	Weekends
Smartphone		
Tablet or iPad		
Computer		
Watching television		
Reading		
Other (Please specify)		
Tic disorder screening		
Screening questions for the first-stage ascertainment for tic disorder		Yes or No
1. Have you ever had (or do you currently have) facial tics, jerks of other parts of the body, or any other unusual movements or habits?		
2. Have your ever found (or do you currently find) yourself involuntarily making noises other than normal talking, like grunts, throat clearing or saying words?		
3. Have you ever found (or do you currently find) yourself wanting to touch objects, other people, or parts of your body repeatedly?		
4. Have you ever sought professional help because of tics/movements/noises?		

was a risk factor for dry eyes[9]. However, there was no previous study that has evaluated the association between visual display terminal use and excessive blinking in children.

Therefore, in the present descriptive cross-sectional case-control study, the authors aimed: 1) to identify the cause of excessive blinking in apparently healthy children, and 2) to evaluate its association with visual tasks including visual display terminal use.

Materials and Methods

Two hundred children aged 6 to 14 years, from an outpatient clinic of King Chulalongkorn Memorial Hospital and Rutnin Eye Hospital between May 2017 and January 2019 were enrolled. There were 100 children with a chief complaint of excessive blinking in the study group and 100 children who had an eye check-up visit in the control group. The exclusion criteria for both groups were children with previous diagnoses of psychiatric or neurological disorders, an insufficient cooperation that would interfere with the examination, insufficient information regarding their daily activities reported by their parents, and a previous treatment for excessive blinking within 1 month.

All parents completed the questionnaire which was divided into 2 parts. The first part assessed the duration of visual display terminals (mobile phone, tablet, and computer) use and reading. Other activities at school were not included. Weekdays and weekend activities were asked separately, then the duration of visual display terminals use and reading were summarized and recorded in total hours per week. The second part composed of screening questions for the first stage ascertainment of tic disorder[10]. The following questions were asked: 1) Have you ever noticed your child having facial tics, jerks of other parts of the body, or any other unusual movements or habits?, 2) Have you noticed your child involuntarily making noises other than normal talking, like grunts, clearing of the throat or saying words?, 3) Have you ever noticed your child wanting to touch objects, other people, or parts of his/her body repeatedly?, and 4) Have you ever sought professional help for your child's tics/movements/noises? (Table 1).

All children underwent a comprehensive eye examination including visual acuity testing, blink rate measurement, slit lamp examination, tear break-up time (TBUT), and intraocular pressure (IOP) measurement. The blink rate was measured while the children were watching cartoon at 6 meters for 1 minute by the authors' research assistants who were masked to the diagnosis. TBUT was performed with fluorescein strip soaked with 0.9% normal saline solution instilled at both lower fornixes. The TBUT was measured in both eyes, 3 times in each eye, and the average was acquired. The lower result of the TBUT in either eye was used for analysis. A slit lamp examination included upper eyelid eversion and fluorescein staining. An IOP was measured by either air-puff tonometer or I-care tonometer. Patients

Table 2. Characteristics of the study group and the control group

Characteristics	Study group (n=100); n (%)	Control group (n=100); n (%)	p-value
Age; mean (SD, range)	7.9 (2.0, 6 to 13)	9.5 (2.3, 6 to 14)	<0.001*
Sex: male	77 (77)	44 (44)	<0.001**
Visual acuity in the worst eye			<0.001**
20/20	52 (52)	85 (85)	
20/25	28 (28)	3 (3)	
20/30	12 (12)	7 (7)	
20/40	2 (2)	4 (4)	
20/50 to 20/80	6 (6)	1 (1)	
Blink rate (blinks/minute); median (IQR)	30 (18 to 42)	9 (6 to 12)	<0.001***
TBUT (second); median (IQR)	4 (3 to 6)	11 (8 to 13)	<0.001***

SD=standard deviation; IQR=interquartile range; TBUT=tear break-up time

* Statistically significant by Student's t-test, ** Statistically significant by chi-square test, *** Statistically significant by Wilcoxon rank-sum test

whose visual acuity was 20/40 or lower in either eye underwent cycloplegic refraction and fundus examination. Facial grimace and other signs of tic disorder were observed during the examination.

The possible associated conditions of excessive blinking were recorded based on symptoms and signs observed by the researcher. The following conditions ailments were assessed: allergic conjunctivitis, dry eyes, refractive error and tic disorder. Allergic conjunctivitis was diagnosed if the patient had complaints of eye itching, had papillary injections at the tarsal conjunctiva, and/or other prominent signs of allergic conjunctivitis. Dry eyes were diagnosed if the average TBUT was ≤5 seconds. Refractive error was diagnosed if the visual acuity was 20/40 or lower in the worse eye and could be improved with correction. Tic disorder was diagnosed if there was at least one positive answer from the tic disorder questionnaire and/or the signs and symptoms were observed during the examination.

The present study was conducted in accordance with the World Medical Association Declaration of Helsinki. The research protocol was approved by the Institutional Review Board of the King Chulalongkorn Memorial Hospital, Chulalongkorn University (IRB number 677/59) and Rutnin Eye Hospital. The present study was registered in the Thai Clinical Trial Registry (TCTR 20171105001). Written informed assent and informed consent were obtained from all the patients and their parents.

The characteristics of both groups were described and reported as frequency (%), mean ± standard deviation (SD) or median (interquartile range; IQR) as appropriate. Student's t-test, chi-square test, or Wilcoxon rank-sum test were used to compare characteristics between groups. Fisher's exact test (f) was used to compare the diagnoses of both groups. The duration of visual activities between groups, were compared by using chi-square test and ordinal logistic regression adjusted for age and sex. The correlation between the TBUT and blink rate, and the relationship between visual task and blink rate were analysed by Spearman's rank correlation. A p-value of less than 0.05 was considered statistically significant. The statistical analyses were performed using Stata, version 14.0 (StataCorp LP, College Station, TX, USA).

Results

One hundred children with excessive blinking and 100 normal children were enrolled into the present study. The baseline characteristics of both groups were shown in Table 2. The children in the study group were younger (7.9 versus 9.5-year-old) and predominantly male (77% versus 44%), compared to the control group. The median blink rate in the study group was significantly higher than the control group [30 (IQR 18 to 42) versus 9 (IQR 6 to 12) blinks per minute, p<0.001]. The median TBUT in the study group was significantly lower than the control group (4 versus 11 seconds, p<0.001). In the study group, the median TBUT was not different between patients who had higher blink rate (≥20 blinks per minute) and patients who had lower blink rate (<20 blinks per minute) (p=0.792). None of the patients wore contact lens.

The possible diagnoses of excessive blinking in the study group and the control group were shown in Table 3. The percentage of patients who had dry eyes, allergic conjunctivitis and tic disorder in the study group were significantly higher than

Table 3. Diagnoses of the study group and the control group

Diagnosis	Study group (n=100); n (%)	Control group (n=100); n (%)	p-value
Dry eyes (TBUT ≤5 seconds)	73 (73)	6 (6)	<0.001
Allergic conjunctivitis	41 (41)	0 (0)	<0.001
Tic disorders	19 (19)	9 (9)	0.042
Uncorrected refractive error	10 (10)	5 (5)	0.179
Epiblepharon	3 (3)	0 (0)	0.246[f]
Others (corneal foreign body, bacterial keratitis)	2 (2)	0 (0)	0.497[f]
Normal exam	5 (5)	80 (80)	<0.001

TBUT=tear break-up time

[f] Fisher's exact test

Table 4. Duration of visual activities of the study group and the control group

Duration of visual activities (hours per week)	Study group (n=92); n (%)	Control group (n=100); n (%)	p-value	Ordinal logit model on visual duration adjusted for sex and age	
				OR* (95% CI)	p-value
Mobile phone + Tablet			0.002	0.71 (0.39, 1.30)	0.266
None	12 (12)	12 (12)			
14 hours or less	52 (52)	36 (36)			
>14 to 28 hours	31 (31)	29 (29)			
More than 28 hours	5 (5)	23 (23)			
Computer			0.195	NA	
None	73 (73)	64 (64)			
7 hours or less	19 (19)	18 (18)			
>7 to 14 hour(s)	4 (4)	7 (7)			
More than 14 hours	4 (4)	11 (11)			
Reading			0.277	NA	
None	9 (9)	14 (14)			
7 hours or less	46 (46)	35 (35)			
>7 to 14 hour(s)	23 (23)	31 (31)			
More than 14 hours	22 (22)	20 (20)			

NA=not available

* Odds ratio (OR) between case and control for the duration level and its 95% confidence interval (CI)

the control group. Dry eyes, which was defined as TBUT ≤5 seconds, were diagnosed in 73% and 6% of the children in the study and the control groups, respectively. Whereas 88% and 34% of the children in the study and control groups had TBUT <10 seconds, respectively.

Of the 100 children in the study group, 48 (48%) had more than one diagnoses: 29 (29%) had allergic conjunctivitis and dry eyes, 10 (10%) had dry eyes and tic disorder, 4 (4%) had dry eyes and refractive error, 2 (2%) had dry eyes and epiblepharon, 1 (1%) had dry eyes, epiblepharon and tic disorder, 1 (1%) had allergic conjunctivitis, dry eyes and refractive error, and 1 (1%) had dry eyes and bacterial keratitis.

The durations of visual activities recorded as hours per week in the study and control groups statistically differed by chi-square test. However, after the Ordinal logit model adjusted for sex and age was used, there were no significant differences of the duration of visual activities between both groups as shown in Table 4. No correlation was found between the duration of visual activities and TBUT in the study group [Spearman's correlation coefficient –0.053 for mobile phone and tablet (p=1.000), 0.052 for computer (p=1.000), and –0.149 for reading (p=1.000)].

Discussion

The blink rate is low in children and increases with age. Normal blink rate in children during visual fixation was reported to be 14.3 blinks/minute in 4 to 6 years-old children[5], 19 blinks/minute in 5 to 14 years-old children[7], and 7 blinks/minutes in 8 to 19 years-old children and young adults[8]. Accordingly, the authors found that the median blink rate in the control group (mean age 9.5, SD 2.3) was 9 (IQR 6 to 12) blinks/minute compared to 30 (IQR 18 to 42) blinks/minute in the study group (mean age 7.9, SD 2.0). The results in the present study supported that there was an actual disparity between the control and the study groups and this difference was not related with age in which the blink rate should be lower in the study group considering the lower mean age in the latter group. In addition, the present study is the first to measure blink rate in children with excessive blinking.

Previous studies reported various causes for excessive blinking in children. The most common causes were tic disorder, anterior segment abnormalities and uncorrected refractive error[1,2]. Coats et al[1] found that the common causes of excessive blinking in 99 children (aged 0.5 to 13 years) were anterior segment and/or lid abnormalities (37%), habit tics (23%), uncorrected refractive errors (14%), intermittent exotropia (11%), and psychogenic blepharospasm (10%). Aghadoost et al[2] found that tic disorder (42%), uncorrected refractive error (33%), ocular surface abnormality such as blepharitis and/or dry eyes (10%), psychogenic (10%) and central nervous system diseases (5%) were the causes of excessive blinking in 60 children aged 3.5 to 16 years[2]. In contrast, Mali et al[4] found no ocular pathology in 91% of 34 children with excessive blinking.

The present study is the first descriptive cross-sectional case-control study that investigated children with excessive blinking and also the first to use TBUT for the diagnosis of dry eyes, and tic disorder screening questionnaire to help diagnose the tic disorder. The authors found that the common causes of excessive blinking were dry eyes (73%), allergic conjunctivitis (41%) and tic disorder (19%). The uncorrected refractive error, lid problems and other anterior segment conditions did not seem to be associated with excessive blinking. The percentages of those conditions between the study and the control groups were not significantly different. Since the authors excluded children with neurologic or behavioral abnormalities in order to be able to compare the study group with the control group, therefore, the result of the present study differed from other studies which found that central nervous system disorder was common in children with excessive blinking[1,2]. Moreover, our study found that excessive blinking occurred more commonly in boys than girls with a ratio of 3:1 which was similar to Coat et al's study which reported that the ratio was approximately 2:1 (boys:girls)[1].

The meta-analysis report regarding the tear film stability in children showed that the fluorescein TBUT in healthy children was 14.6 seconds[11]. However, two studies conducted in Asia showed a significantly lower TBUT compared to other studies. In the Korean study, the TBUT was 9.2 seconds[9]. In the Chinese study, the TBUT was 10.0 seconds[12]. In the present study, the TBUT in normal children was 11 seconds which was comparable to the previous studies conducted in Asia. There was a study conducted in adults which reported that Asians have more dry eyes than Caucasians which may potentially be from the poor meibomian gland function and the higher degree of incomplete blinking among Asians[13].

The present study is the first to show that the majority of children with excessive blinking had dry eyes. The criteria of TBUT (≤5 seconds) for the diagnosis of dry eyes used in the present study followed the recommendations from the Asia dry eye society[14]. By using that aforementioned criteria, 73% of the children with excessive blinking were diagnosed with dry eyes. However, if the authors used the criteria of TBUT <10 seconds instead, the percentage increased to 88%. Nevertheless, the authors did not consider using the ocular surface epithelial damage and dry eye questionnaire to support the diagnosis of dry eyes in the present study because they both related to the diagnosis of allergic conjunctivitis.

Though, the authors speculated that an excessive blinking could be a cause of a tear film instability, there was a previous study conducted in adults showed that the blink rate did not significantly correlate with any ocular surface parameter[15]. On the other hand, the tear evaporation was reported to increase with increasing blink rate in patients who had relatively dry ocular surface[16]. The incomplete blinking was also noted to contribute to tear film instability[17]. Therefore, future study needs to consider the followings: 1) use of more invasive tests in children such as the Schirmer test, tear film osmolarity and tear evaporation, which could helped in the diagnosis and treatment but are less applicable in children; 2) comparison of the parameters between the complete

and incomplete blinking groups; and 3) assessment of the result of treatment in the follow-up visit.

The authors found that 41% of children with excessive blinking had allergic conjunctivitis. Most of them had TBUT ≤5 seconds (73%) and all of them had TBUT <10 seconds. The present study result corroborates the findings reported from the previous studies that there was a significant lower TBUT level in children with allergic conjunctivitis[12,18,19]. The mechanism is believed to be due to an increase in inflammatory cytokines that induce goblet cell loss and tear volume insufficiency[18].

In the present study, 9% of the normal children had tic disorder which was in agreement with the previous studies that reported the prevalence of tic disorder in children to be 3.0% to 9.9%[20-22]. In children with excessive blinking, 19% of them had tic disorder which is comparable to a previous study[1]. However, 5% of the present study patients had unknown cause. It is possible that they may have a tic disorder because it has been reported that 86% of excessive blinking children with normal eye exam were diagnosed with the tic disorder by a psychiatrist[23]. Thus, the psychiatric consultation should be considered for children with long-standing excessive blinking.

A previous study reported that the TBUT decreased and the risk of dry eyes increased in adults with prolong use of visual display terminals[24]. Other studies also reported that the visual display terminal use in children was also a risk factor for dry eyes[9] and significantly associated with headache and eye fatigue[25]. However, the present study did not find any association between excessive blinking and duration of visual activities, either using visual display terminal or reading (Table 3). In addition, no correlation was found between duration of visual activities and TBUT in the study group [Spearman's correlation coefficient –0.053 for mobile phone and tablet (p=1.000), 0.052 for computer (p=1.000), and –0.149 for reading (p=1.000)].

The authors found that dry eye syndrome was the most common cause of excessive blinking in children, followed by allergic conjunctivitis and tic disorders. TBUT and tic disorder screening questionnaire are helpful in diagnosing the problem accurately. Boys are three times more likely to have excessive blinking compare to girls. There was no association between the duration of visual display terminal use and excessive blinking in children. The results of the present study could help ophthalmologists in managing the excessive blinking in children more precisely.

What is already known on this topic?

Excessive blinking in children is one of the most common chief complaints in pediatric ophthalmology department. Causes of excessive blinking in children previously reported were: central nervous system disorders, habit tic, uncorrected refractive error, allergic conjunctivitis, psychiatric disorders, stress, and intermittent exotropia or exophoria. Blink rate normally increases with age and differs by various visual activities. The visual display terminal use was reported to be associated with dry eyes. However, those prior studies assessed excessive blinking only in the symptomatic children with no control group and no previous study evaluated its association with the visual display terminal use.

What this study adds?

This study found that dry eye syndrome was the most common cause of excessive blinking in children, followed by allergic conjunctivitis and tic disorders. The tear break-up time and tic disorder screening questionnaire are helpful in diagnosing the problem. Boys are three times more likely to have excessive blinking compared to girls. There was no association between the duration of visual display terminal use and excessive blinking in children. The results of this study could help ophthalmologists in managing the excessive blinking in children more precisely.

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Conflicts of interest

The authors disclose no conflicts of interest.

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