Original Article

Prevalence and Associated Risk Factors of Digital Eye Strain among Children in Secondary Schools in Pathumthani Province, Thailand

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Background: Digital Eye Strain (DES) is one of the health effects from overuse of digital devices. Although the use of digital devices and the visual problems have been reported among adults in many studies, DES is rarely investigated in children.

Objective: To determine the prevalence and associated risk factors of digital eye strain (DES) among the lower secondary school students.

Materials and Methods: The present report was an analytical cross-sectional study, employed self-administered questionnaires to determine the prevalence and associated factors of digital eye strain among students in lower secondary schools. Data were collected from 15 June to 30 August 2016 in 3 schools in Pathumthani province, Thailand. Data were analyzed by Chi-square test and multivariate regression to show the relationship between studied variables and digital eye strain.

Results: There were total of 550 questionnaires collected (94.01% responsed rate). The symptoms of DES were reported among 460 students (94.84%). The associated risk factors of DES when analyzing with multivariate logistic regression were gender (adjusted OR 3.88, 95% CI 1.38, 10.92), viewing distance (adjusted OR 3.57, 95% CI 1.28, 9.93) and duration of use on weekend over 2hr per day (adjusted OR 7.62, 95% CI 3.25, 17.82).

Conclusion: The prevalence of DES in the lower secondary school students was as high as in adults. In Thailand, there are no guidelines on the use of digital devices especially smartphones. Therefore, the present study recommends that smartphone use should be less than 2 hours/day and viewing distance more than 34 mm in order to protect health hazards from smartphone.

Keywords: Digital eye strain, Viewing distance, Children, Smartphone

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Digital Eye Strain (DES) is one of the health effects of overusing digital devices. The symptoms include physical and eye discomfort after two or more hours in front of a digital screen, including eyestrain, irritate eye, watering eye, dry eye, blurred vision, double vision, headache, neck and shoulder pain[1,2]. The literature review revealed that children aged 10-15 years who using digital devices had health effects similar to adults[3-5]. The health effects can be either temporary or permanent visual problems[6,7]. According to the report in Thailand during 2009-2013, smartphone usage among children increased every year, but there were few reports about harmful health effects[8,9] and no diagnoses and records of DES were found in the ICD-10 code in Thailand. In 2013, a study in outpatient's ophthalmology department at a super tertiary care hospital in Thailand showed the children aged 12-15 years who visited the doctors with 313 cases of eye and visual problems[8]. The report revealed that the cause of visual problem, i.e., eye strain, tired eyes, and blurred vision caused by heavy smartphone usage and with regardless of use. The present also found all of them used the devices for a long time and were not concerned about the health

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effects[8]. Self-protection is limited because children are naturally unaware of the health-related consequences. However, prolonged use of digital devices may be inappropriate for children's physiological conditions and development. Although the digital device use and visual problems have been reported in many studies among adults, DES in particular is rarely investigated in children. The objectives of the present study were to determine the prevalence and associated risk factors of digital eye strain among students in secondary schools in the Greater Bangkok region of Thailand and to offer recommendations to prevent and reduce health effects from smartphone usage.

Materials and Methods

Study population

There were 5,146 students in the secondary educational 4th service area in Klongluang District, Pathumthani Province. A cross-sectional study was carried out in 3 secondary schools.

Data collection and measurement

The sample size was calculated using a formula proposed by Krejcie and Morgan (1970). The present study was set at 10 percent of Type I error. The calculated sample size was at least 360. Total of 585 self-administered questionnaires were sent out, 550 questionnaires were completed and returned. Respondents were asked to take the visual acuity test by Snellen chart at 6 meters. The inclusion criteria were students aged 12-15 years (grade 7-9), who used any kind of digital devices. These students were asked to report all their DES symptoms over the past one year, in order to calculate the one-year prevalence of DES. The criteria for DES as defined by the American Optometric Association[1,2] were applied in this study. Students who had acute eye injury and could not complete the visual acuity measurement were excluded. This study was approved by Thammasat University Human Research Ethic committee (No: 3 Faculty of Nursing). Data collection was taken from 15thJune to 30th August, 2016. The questionnaire consisted of three parts. The first part consisted of 16 items on demographic data and individual characteristics including age, gender, weight, height, school, level of education, underlying disease, visual acuity, eye correction and exercise. The second part included 11 items on the characteristics of using smartphone, such as brands and model of smartphone, screen size, duration of use per day on weekday and weekend (hours), relaxation, activities among using smartphones. The answers would range from "never", "sometimes", and "always". The third part included 10 symptoms on the DES data. The result of experience at least 1 symptom will be concluded as the DES strain[10,11]. Ten DES symptoms after screen use consisted of; eye strain, irritate eye, photophobia, dry eyes, watery eye, blurred vision, red eye, headache, neck and shoulder pain[1,2]. The questionnaire was verified by 3 lecturers with experience in the field of occupational health services and ophthalmologists. Their comments and suggestions were used to revise the questionnaire before being tried out with a pilot group of 40 students from a school not included in the target groups in this study. Content validity and reliability of the questionnaire were assessed using the IOC index and Cronbach's alpha, respectively. The IOC value ranged from 0.85 to 1, while Cronbach's alpha was between 0.68 and 0.72.

Statistical analysis

All data from the present study were analyzed using the SPSS software version 20. Descriptive statistical measures were used to analyze the data, such as percentage, frequency, mean, standard deviation (SD), and prevalence rate of digital eye strain. Chi-squared test was used to determine the relationship between independent variables (i.e., demographic factors, characteristic of digital device use, environmental factors) and digital eye strain symptoms. The odds ratio (OR) and 95% confidence interval (CI) were reported. The multivariate logistic regression analysis was used for predicting the risk factors of the relationship between the risk factor of digital eye strain on a one-year prevalence of DES. The variables that associated with DES at the 0.2 level from the univariate analysis were selected into multiple logistic models. All reference levels were coded as OR = 1. The Wald test was used for testing the significant level and compared with the reference level for each of the parameters. All tests were set for a significance level α at 0.05.

Results

All participants consisted of grade 7-9 students from 3 schools in the secondary educational 4th service area office, Klongluang, Pathumthani province, Thailand. There were total of 550 returned questionnaires (94.01% response rate). The eleven questionnaires were excluded because they did not use smartphone (2 %). Forty-four (9.81 %) were also excluded due to the absence of the DES symptoms and duration of digital device usage (9.45 %). The one-year prevalence of

digital eye strain (DES) was 460 cases (94.84%). The most common complaints in smartphone users were neck pain (73.2%), followed by eye strain (70.3%) and eye irritation (60.2%). All participants' mean age was 13.24 (±SD 0.88) years. There were 218 males (44.9%) and 267 females (55.1%). The factor of digital device use over 1 year was 386 (79.58%), weekday use over 2 hours per day 342 (70.51%), and weekend use 431 (88.86%). The abnormal visual acuity was 298 (61.44%). The smartphone display size over 5 inches was 196 (40.41%).

Results of the univariate analysis of one-year prevalence and the significant relationship between personal factors and DES were shown in Table 2. The personal factors consisted of male (crude OR:5.29, 95% CI 1.95, 14.34), abnormal visual acuity (crude OR:1.78, 95% CI 0.79, 3.99), wearing glasses (crude OR:0.19, 95% CI 0.02, 1.46), indoor environment (OR = 2.77, 95% CI; 0.98, 7.81), inappropriate temperature (crude OR:1.65, 95% CI 0.38, 7.22), scratched on screen (crude OR:1.81, 95% CI 0.80; 4.09), viewing distance less than 34 centimeters (OR = 4.19, 95% CI 1.65, 10.66), time of use per year more than 1 year (crude OR:1.92, 95% CI 0.79,4.56), time to use in weekday and weekend more than 2 hours per day (crude OR:2.75, 95% CI 1.22, 6.18) and (crude OR:7.26, 95% CI; 3.25, 17.18). All variables with a p-value ≤ 0.2 in the univariate analyses were further analyzed by multivariate logistic regression in Table 3. The results revealed that the female gender (adjusted OR 3.88, 95% CI 1.38, 10.92), the distance from eyes over 34 centimeters (adjusted OR 3.57, 95% CI 1.28, 9.93) and use time/day (hour) on weekend over 2 hour (adjusted OR 7.62, 95% CI 3.25, 17.82) were the associated risk factor of DES.

Table 1. Demographic data, personal factors and findings of students and smartphone characteristics (n = 485)

Factor	Number (%)
Age (year) (Mean±SD)	13.24±0.88
Gender	
Female	267 (55.10)
Male	218 (44.90)
Education	
Grade 7	184 (37.94)
Grade 8	180 (37.11)
Grade 9	121 (24.95)
Visual acuity	
Abnormal	298 (61.44)
Normal	187 (38.56)
Allergy	
Yes	71 (14.64)
No	414 (85.36)
Exercise	
Yes	407 (83.92)
No	78 (16.08)
Digital eye strain (DES)	
Yes	460 (94.84)
No	25(5.76)
Smartphone display size (inch)	
≥5	289 (59.59)
<5	196 (40.41)

Discussion

The present study was conducted on 3 schools under the secondary educational 4th service area office, Klongluang, Pathumthani province, Thailand. The one-year prevalence of DES was 460 (94.86%) similar to DES among adults in Thailand[12-14] and other countries[15-18]. The significant associated factors of DES were gender, viewing distance, and use time (hour) per day in weekend.

Compared to the male group, the female group was associated with an increased risk of the digital eye strain symptoms (Adjusted OR, 3.88; 95% CI 1.38, 10.92). The present result is consistent with the studies of Venkatesh et al (2016)[18] and Shantakumari et al (2011). The result is explained by the prevalence of accommodative and vergence dysfunction for females group were found the higher than males, also the visual discomfort were found increasing among female[19].

The viewing distance factor between eye and screen less than 34 centimeters was associated with DES (Adjusted OR, 3.57; 95% CI 1.28,9.93). The present study agreed with the study of Jeong (2010)[20]. The reading on a screen required more concentration than paper. In close distance, the eyes must coordinate movement of two eyes (Convergence) and focus for clear the image (accommodation). The government of the Hong Kong special administrative region, for instance, recommended the comfortable viewing distance from the monitor should be about 30 centimeters. Similar to the study by Dora et al (2016) that recommended about 33.8 centimeters from eyes[21].

Table 2. One year prevalence of Digital eye strain distributed by personal factors, environmental factors and smartphone use factors (n = 485)

Factors	Total (n)	1 year prevalence (n)	%	Crude OR (95% CI)	*p*-value
Gender					
Male	218	198	43.0	1	
Female	267	262	57.0	5.29 (1.95,14.34)	<0.01*
Visual Acuity					
Normal	187	174	37.8	1	
Abnormal	298	286	62.2	1.78 (0.79,3.99)	0.16
Wear glasses					
Glasses	82	81	82.4	1	
No	403	379	17.6	0.19 (0.02,1.46)	0.11
Allergic rhinitis					
No	414	391	85.7	1	
Yes	71	66	14.3	0.67 (0.24,1.84)	0.43
Place of main use					
Outdoor	43	38	8.3	1	
Indoor	442	422	91.7	2.77 (0.98,7.81)	0.05
Lighting in use area					
Appropriated	425	402	87.4	1	
Inappropriate	60	58	12.6	1.65 (0.38,7.22)	0.50
Light direction					
From the front	334	317	68.9	1	
From the side	73	70	15.2	1.25 (0.35,4.38)	0.73
From behind	78	73	15.9	1.59 (0.36,6.94)	0.53
Temperature in work area					
Appropriated	400	382	83.1	1	
Inappropriate	85	78	16.9	0.52 (0.21,1.30)	0.16
Smartphone display size (inch)					
≥5	196	186	40.4	1	
<5	289	274	59.6	0.96 (0.43,2.23)	0.96
Resolution					
HD - ≥HD	153	314	68.3	1	
<HD	332	146	31.7	0.83 (0.34,2.04)	0.69
Scratched on screen					
No	150	139	30.2	1	
Yes	335	321	69.8	1.81 (0.80,4.09)	0.15
Reflection on screen					
No	305	289	62.8	1	
Yes	180	171	37.2	1.05 (0.45,2.43)	0.90
Flicker of letter					
No	443	421	91.5	1	
Yes	42	39	8.5	0.67 (0.19,2.37)	0.54
Viewing distance from screen					
≥34 cm	46	39	8.5	1	

Table 2. (continued)

Factors	Total (n)	1 year prevalence (n)	%	Crude OR (95% CI)	*p*-value
<34 cm	439	421	91.5	4.19 (1.65,10.66)	<0.01*
Taking breaks					
Yes	435	413	89.8	1	
No	50	47	10.2	0.83 (0.24,2.89)	0.77
Duration of use (Year)					
<1	99	91	19.8	1	
≥1	386	369	80.2	1.90 (0.79,4.56)	0.14
Use time/ day (Weekday) (hours)					
<2	143	130	28.3	1	
≥2	342	330	71.7	2.75 (1.22,6.18)	0.01*
Use time/ day (Weekend) (hours)					
<2	54	43	9.3	1	
≥2	431	417	90.7	7.62 (3.25,17.82)	<0.01*

* The p-value were based on the Chi-square test
HD= High-Definition

Table 3. Adverse events related with anesthesia provider in university hospital and tertiary hospital (n=57)

Risk factor of DES	n	Crude OR (95%CI)	Adjusted OR (95% CI)	*p*-value
Gender				
Male	218	1	1	-
Female	267	5.29 (1.95,14.34)	3.88 (1.38,10.92)	0.01*
Viewing distance from screen				
≥34 cm	46	1	1	-
<34 cm	439	4.19 (1.65,10.66)	3.57 (1.28,9.93)	0.01*
Use time/ day (Weekend) (hours)				
<2	54	1	1	-
≥2	431	7.62 (3.25-17.82)	7.34 (2.99,18.01)	<0.01*

* The *p*-value was based on the Wald Chi-squared test.
Adjusted OR = adjusted odds ratio, Crude OR = crude odds ratio
95% CI = 95% confidence interval

The duration of digital use is directly related to DES[22]. The main cause of DES is fatigue of the ciliary and extra ocular muscles due to the prolonged accommodation and vergence by near vision work[14]. In the present study, using smartphone longer than 2 hours daily on weekends was significantly associated with occurrence of DES with odd ratio of 7.34 (95% CI 2.99,18.01). It was similarly reported with Hakala et al (2010)[23].

The first limitation of the present study was it was a cross-sectional design that was difficult to imply the cause–effect relationship. Second, the symptoms were assessed by responses to a self-administered questionnaire. Third, the selection of the sample was limited and based on the convenient-sampling method. For further study, cohort study design could be suggested for the proper the relationship bias risk factors. The clearly diagnose by ophthalmologist would be better than self-reported symptoms.

Conclusion

The present study found high prevalence rate of DES among secondary school students in Pathumthani Province. From all of three schools, 460 students were found DES (94.84%). The present study also found all of them used the devices for a long time and did not take environment into account during usage. The nature of children's eyes was different from adults.

The maintaining self-defense among children were still limited. Moreover, the existing laws are only applied for working adults. Therefore, it is necessary to make some recommendations for teachers and parents to pay more attention to the physiological needs of the children. The authors hope this paper would be useful for children and parents in reduction of use time, increase viewing distance to be more than 34 centimeters. These are recommend for use digital devices.

What is already know on this topic?

None in Thailand.

What this study adds?

This study indicated that the prevalence of DES among secondary school students in Pathumthani Province were 460 (94.84%). Gender, viewing distance and time per day in weekend were the factors significantly associated with DES.

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Potential conflicts of interest

The authors declare no conflict of interest.

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