Introduction
Dry eye disease (DED) is one of the most commonly encountered ocular morbidities in an ophthalmology clinic. About 25% of patients who come for eye check-up report with dry eye symptoms, making it a growing public health concern and one of the most common conditions seen by ophthalmologists. Although, dry eye disease has usually been considered a disease of the elderly and the post-menopausal women, of late there has been a rise in patients presenting with dry eye symptoms in the paediatric age group.

Materials and Methods
It was a prospective, quasi-experimental study including 78 diagnosed patients of dry eye disease in the age group of 5-15 years, attending out-patient department (OPD) of a tertiary care eye hospital in Cuttack, Odisha during July 2016 to March 2017. The study was done with the approval of the institutional ethics committee. During the study period, a total of 735 patients, in the age group 5-15 years, attending out-patient department (OPD) with the chief complaints of redness, itching, watering, and foreign body sensation were examined. A thorough history was taken, the signs and symptoms were evaluated and the patients were subjected to questionnaires. Questionnaires were designed to obtain information regarding mean daily duration of video display terminal use, learning (reading and writing), outdoor activities, and past history of allergic disease and anti-histamine drug use.

Results
Of the 78 children (43.6% rural & 56.4% urban) 88.4% belonged to Category A and 11.6% to Category B. Mean IBI in Category A was 2.89s & in Category B it was 4.32s, mean TBUT was measured at 8.87 s and 9s in both the categories respectively, and a Schirmer’s value of <10mm without anaesthesia in both the categories. Patients were reviewed again after discontinuing use of smartphone for 1 month. Improvement in symptoms and dry eye scores noted with the values being statistically significant (p<0.05).

Conclusion
Smartphone use continuously for longer time can lead to symptoms of DED in children. With increasing smartphone use among younger population this is a cause of concern.

Keywords: Smartphone, dry eye, Schirmer’s test.
evaluated at presentation for fluorescein corneal staining, tear film break-up time (TBUT), Schirmer's test (ST), and inter-blink interval (IBI). Dry eye disease was diagnosed in patients with TBUT of less than 10 seconds, Schirmer's test value of less than 15mm, positive corneal and conjunctival staining,(any two of the above) and modified OSDI score more than 20. Inter-blink interval was measured by averaging the number of total number of blinks observed for half-an-hour. Patients were advised to avoid smartphone use for 1 month. After cessation, the parameters were evaluated and compared again at the end of 1 month. No additional therapy (lubricants or anti-allergic medications) was provided to them during the period. All parameters were measured by a single observer.

Refractive error, if any, was also recorded as per questionnaire. Those with uncorrected errors were provided with glasses before including them into study group.

For ease of comparison and to better elicit the relationship between dry eye disease and smartphone use, the patients were divided into two categories: Category A, for those using smartphone continuously for more than or equal to 1 hour, continuously, at any given time, and Category B, for those using it for less than 1 hour continuously, at any given point of time. The inclusion and exclusion of patients into this study were decided as per the following criteria.

**Inclusion criterion**
- Patients diagnosed with DED between 5-15 years of age.

**Exclusion criteria**
- Children who underwent any type of eye surgery in the past six months.
- Children who had nocturnal lagophthalmos.
- Children who had eyelid problems like trachoma, trichiasis, distichiasis or epiblepharon.
- Children who had allergic conjunctivitis with the use of antihistaminic drugs.
- Contact lens wearers.
- Children who had any congenital, endocrine or autoimmune disease.

Figure 1 shows the flowchart of the methodology used in a concise manner.

**Statistical Methods**
Clinical information, including complete ophthalmic examination along with demographic details, was entered into the spreadsheets in Microsoft Excel. The statistical analysis employed SPSS software, version 16.0 (SPSS Inc., Chicago, Illinois, USA). Student’s t-test was used to compare means among groups. A p value of less than 0.05 was considered significant.

**Results**
Of the 78 patients, 69 cases belonged to category-A whereas 9 cases belonged to category-B, as shown in Figure 2. The mean age of patients in category-A was 11.5 ± 1.6 years and that of patients in category B was 13.5 ± 0.8 years.

Figure 3 shows the sex distribution of patients in both the categories. In category-A, 78.3% were male and 21.7% were female. In category-B, 77.8% were male and 22.2% were female. Patients from urban area were 44 in number (56.4%), of which 43 cases belonged to category-A and from rural area were 34 in number (43.4%), of which 26 cases belong to category-B.

15 children (19.2%) were found to suffer from refractive errors. The distribution is shown in Figure 4. 54% were found to be myopic with a spherical equivalent: -2.21±1.45D. All cases belonged to category-A.

It was observed, as shown in Figure 5, that the average duration of time spent during outdoor activities was greater in Category B, with a mean 2.10 hours as compared to a mean
of 1.32 hours by the children in Category A, while the time spent on smartphones and other visual display terminal use was higher (mean of 5.33 hours) in Category-A as compared to that of Category-B (mean of 3.28 hours). It was statistically significant with p<0.001 by independent t-test.

The parameters of study noted before and after cessation of smartphone use in both the categories also showed remarkable change, as shown in Table 1 and Table 2. Mean TBUT was recorded at 8.87±0.55s in category-A that later improved to 10.26±0.34s, with an improvement in 92.1% of subjects (p<0.0001). Those in category-B recorded a higher mean TBUT at 9.0±0.7s at baseline, which further improved to 10.89±0.93s on cessation (p=0.002). Mean IBI at baseline for category-A was recorded at 2.89±0.08s which improved to 4.31±0.19s, (p<0.0001). Mean IBI was recorded at 4.32±0.19s at baseline in category-B; later improved to 5.34±0.32s (p<0.0001).

Similarly values in ST also showed improvements in both categories. It improved from 8.7±0.8 to 13.3±0.9 in Category-A (p<0.0001) and from 9.5±0.7 to 14.8±0.8 in Category-B (p<0.0001). Fluorescein staining was reported in Category-A mostly, 78.26% of which showed no staining after cessation of smartphone use for a month.

Table 3 shows that the OSDI scores also showed significant results in favour of smartphone cessation. There was 54.7% decrease in mean OSDI score in category-A (p<0.001) and 60.2% decrease in mean OSDI score in category-B (p<0.004). Statistical significance calculated by independent t-test.

**Discussion**

Many studies have earlier been carried out to establish the clinical condition of computer vision syndrome as well as the ocular fatigue associated with the use of visual display terminals. However, the connection between the usage of smartphones and the development of dry eyes was first established in the landmark study by Moon et al. They had established a total of 6.6% with dry eye disease, while our study showed a larger number with 10.6%.10 In their study, Moon et al had found that 86.7% of those developing dry eyes belonged to urban areas, whereas only
13.3% belonged to rural areas (p=0.03).\textsuperscript{10} Our study differed with 56.4% belonging to urban areas and 43.6% belonging to rural areas with no statistical significance. Females comprised of 53.4% of the affected as compared to 21.8% in our study.\textsuperscript{10}

Prevalence of spectacle use was also found to be higher in those with DED, across various sub-groups, in the study by Moon et al. Spherical equivalent varied from −2.13±2.34D to −1.77±2.12D. In our study too, maximum cases with refractive error were found to be myopic (Spherical equivalent: −2.21±1.45D).\textsuperscript{10} Prevalence of dry eye was also found to be more in myopic children in the study by Fahmy et al.\textsuperscript{16} Moon et al observed that an average of 5.46 hours was spent on smartphone and VDTs and a meagre 1.47 hours on outdoor activities in the affected group. Similar values were noted in the Category-A of the affected group in our study with an average of 5.33 hours spent on smartphones and VDTs and 1.32 hours spent outdoors.\textsuperscript{10} The values in both studies were statistically significant, with the study by Moon et al showing significance for both smartphone usage and VDTs separately (p=0.027 and 0.001, respectively), even though they could not establish a relation between risk of dry eye disease and daily television and computer use.\textsuperscript{10}

They observed that increased outdoor activity time reduced the rate of pediatric DED (OR = 0.33).\textsuperscript{10}

In their study of effect of cellular videogames played on smartphone on dry eye symptoms by Park et al, a difference of frequency of blinking, dry eye symptom scores and amount of tears was noted (p<0.001), with the measurements conducted 61 minutes after continued smartphone use.\textsuperscript{13} This probably gives an insight as to why the major proportion of children diagnosed with DED fell under category-A.\textsuperscript{13}

Following cessation of smartphone use, Moon et al observed that a significant reduction in the number of DED patients with punctate epithelial erosions (PEEs) (p<0.001) and TBUT (p<0.001) which reduced from 10.00±3.25 s to 11.33±2.29 s on cessation of smartphone. Similarly in our study, the mean TBUT had increased, in both categories, following cessation of smartphone use.\textsuperscript{10}

Change in OSDI scores following cessation of smartphone use was clinically significant in our studies (Cat – A: p<0.001; Cat – B: p=0.004). It was also found to be clinically significant (p<0.001) and had reduced from 30.74±13.36 to 14.53±2.23 in the study by Moon JH et al.10

The mean inter-blink interval also improved from 2.89 to 4.58 s in category-A and from 4.32 s at baseline to 5.34 s in category-B, following smartphone cessation with the improvement of dry eye symptoms. They were comparable with the previous studies by Tsubota et al, who had recorded a mean IBI of 4.0 s and 1.5 s for normal and dry eye respectively and Johnston et al, with values of 5.97 s for normal versus 2.56 s for dry eyes.\textsuperscript{14,15}

Despite the best of our abilities, our study had its own limitations. Since DED has been known to co-exist with allergic conjunctivitis, there are likely chances of overestimation of the diseased group.\textsuperscript{8} Moreover, the study had been conducted in a tertiary care hospital of coastal Odisha wherein the effect of relative humidity weighs higher as compared to places that experience dry heat. Confounding factors like socio-economic status and relative humidity were not taken into account.

**Conclusion**

Increased use of smartphones is a serious issue that can result in ocular surface symptoms, especially in paediatric age group. Continuous use is found to be more detrimental than intermittent use or judicious use with enough breaks to avoid ocular fatigue. Therefore, close observation and caution should be practiced when allowing children to use smartphones.

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