Clinical Optometry

Dovepress
Taylor & Francis Group

Open Access Full Text Article

RESPONSE TO LETTER

Objective Evaluation of Relationship Between Tear Film Stability and Visual Fatigue [Response to Letter]

Maki Watanabe[1], Masakazu Hirota[2–5], Ryusei Takigawa[2], Kanako Kato[2], Yuka Ikeda[2]

[1]Division of Orthoptics, Graduate School of Medical Care and Technology, Teikyo University, Itabashi-ku, Tokyo, Japan; [2]Department of Orthoptics, Faculty of Medical Technology, Teikyo University, Itabashi-ku, Tokyo, Japan; [3]Department of Ophthalmology, School of Medicine, Teikyo University, Itabashi-ku, Tokyo, Japan; [4]Graduate Degree Program of Health Data Science, Teikyo University, Itabashi-ku, Tokyo, Japan; [5]Graduate Degree Program of Comprehensive Applied Data Science, Teikyo University, Itabashi-ku, Tokyo, Japan

Correspondence: Masakazu Hirota, Department of Orthoptics, Faculty of Medical Technology, Teikyo University, 2-11-1 Kaga, Itabashi, Tokyo, 173-8605, Japan, Tel +81 03 3964 1328, Fax +81 03 3963 0303, Email hirota.ortho@med.teikyo-u.ac.jp

Dear editor

We thank Drs. Bandyopadhyay, Jaman, and Chaurasiya for their thoughtful commentary on our study. Their constructive feedback provided valuable insights that will help advance research in this important area of digital eye strain.

The sample size was determined using Power and Sample Size software (Vanderbilt University, Nashville, TN, USA), and the required values were referenced from a previous study by Hirota et al.[1] We planned a study of a continuous response variable from matched pairs of study participants. Prior data indicated that the difference in the responses of the matched pairs had a standard deviation of 0.106. If the true difference in the mean response of the matched pairs is 0.132, we need to study nine pairs of participants to reject the null hypothesis that the response difference is zero with a probability (power) of 0.9. The Type I error probability associated with this test of the null hypothesis was 0.05. Therefore, although our sample size was limited to 11 participants, we believe that the statistical power was adequate for detecting meaningful differences in this young, healthy population.

We agree with your comments on participants' characteristics. The participants in this study were individuals in their early 20s, making it difficult to generalize the results to a broader age range. Furthermore, we did not evaluate the participants with binocular vision disorders. Therefore, to conduct a comprehensive assessment of visual fatigue, participants with diverse characteristics and conditions must be included.

We agree with your comments regarding visual task duration. In this study, we employed a 30-min visual task as the minimum duration necessary to induce measurable visual fatigue. Previous studies have reported significant changes in tear film stability, blink rate, and blink quality (complete or incomplete) after 60 min of visual tasks.[2] Therefore, it is important to evaluate these parameters over extended periods of 30 min or longer. The blink rate during visual tasks can be calculated using eye-tracking technology. We plan to develop an algorithm to identify complete and incomplete blinks using Python. In future studies, we plan to investigate the temporal changes in tear film stability and blinking over longer exposure durations.

This study did not conduct any questionnaires because the purpose was to evaluate only objective data. As you pointed out, we have also considered that consistency with subjective results is important. In future studies, we would like to use the OSDI for subjective evaluation of dry eye. For subjective questionnaires, we would like to use either the CVS-Q or a questionnaire created based on previous studies.[1,3–5]

We believe that tear film instability is the main cause of visual fatigue. Regarding other causes, we agree with your observation that there may be a burden on regulations and congestion. However, it is difficult to evaluate accommodation and convergence in an experiment on visual fatigue, as placing strain on accommodation and convergence can cause visual fatigue. Therefore, we plan to develop equipment capable of assessing VAC, as reported by Hoffman et al,[5] and to evaluate VAC during visual tasks.

Received: 5 August 2025
Accepted: 18 August 2025
Published: 3 September 2025

Funding

This work was supported by Early-Career Scientists, Scientific Research (A) and (B), Japan Society for the Promotion of Science (22K18231 [M.H.], 20K04271 [M.H.], 22H00539 [M.H.]); Nakatani Foundation (M.H.); Inamori Foundation (M.H.); Japan Medical Herb Association Research Grant Program (M.H.); TERUMO LIFE SCIENCE FOUNDATION (22-III 1009 [M.H.]); Intensive Support for Young Promising Researchers, Japan Agency for Medical Research and Development (23he0422031j0001 [M.H.]); The Science Research Promotion Fund, The Promotion and Mutual Aid Corporation for Private Schools of Japan (M.H.); Bayer Retina Award (M.H.); and Takeda Science Foundation (M.H.).

Disclosure

M.H. reports patents WO2017159225 and US10959615 licensed to Topcon Corp. The authors report no other conflicts of interest in this communication.

References

1. Hirota M, Morimoto T, Kanda H, et al. Objective evaluation of visual fatigue using binocular fusion maintenance. *Transl Vis Sci Technol*. 2018;7:9. doi:10.1167/tvst.7.2.9
2. Hirota M, Uozato H, Kawamorita T, Shibata Y, Yamamoto S. Effect of incomplete blinking on tear film stability. *Optom Vis Sci*. 2013;90:650–657. doi:10.1097/OPX.0b013e31829962ec
3. Nakazawa T, Okubo Y, Suwazono Y, et al. Association between duration of daily VDT use and subjective symptoms. *Am J Ind Med*. 2002;42:421–426. doi:10.1002/ajim.10133
4. Sheedy J, Bergstrom N. Performance and comfort on near-eye computer displays. *Optom Vis Sci*. 2002;79:306–312. doi:10.1097/00006324-200205000-00010
5. Hoffman DM, Girshick AR, Akeley K, Banks MS. Vergence-accommodation conflicts hinder visual performance and cause visual fatigue. *J Vis*. 2008;8:31. doi:10.1167/8.3.33

https://doi.org/10.2147/OPTO.S558482