ORIGINAL ARTICLE

Evaluating the Tobii Pro Fusion-120Hz Eye Tracker for Clinical Use

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ABSTRACT

Background: This study aims to evaluate the performance of the Tobii Pro Fusion-120Hz in producing normative data for saccadic peak velocity, with the results compared to the higher sampling rate EyeLink 1000 Plus, which has already been validated for clinical use. **Methods:** Thirty participants (aged 20-23) with normal ocular motility and best-corrected visual acuity of 0.2 log MAR or better were recruited. Exclusion criteria included high myopia, ocular trauma, brain injuries, and the use of rigid gas-permeable contact lenses. Saccadic movements were measured using the Tobii Pro Fusion-120Hz eye tracker. Data were recorded and analysed using Tobii Pro Lab Software and SPSS version 23. Calibration accuracy and precision thresholds were set at 0.5° and 0.2°, respectively. Participants completed 24 saccadic trials tested binocularly, and the recorded peak velocity data was compared with data validated using the higher sampling rate devices (500Hz). **Results:** The one-sample t-test showed no significant difference in saccadic peak velocity ($p = 0.40$) between the lower sampling rate and the higher sampling rate, indicating that the former can produce saccadic peak velocity measures comparable to those of the latter. **Conclusion:** Normative data for saccadic peak velocity were provided in this study using the Tobii Pro Fusion-120Hz, confirming its accuracy for clinical assessments and its potential for clinical application.

Keywords:
saccadic peak velocity; eye-tracking; EyeLink 1000 Plus; Tobii Pro Fusion-120Hz; ocular motility

INTRODUCTION

Eye movements are integral to the ability of the visual system to produce a single, clear image. Among these movements, saccades are rapid, voluntarily initiated eye movements that bring target objects into the fovea, enabling clear vision of moving objects. Saccadic movements are characterized by latency, peak velocity, and accuracy (Shafee, 2021). These parameters are critical for detecting eye movement anomalies, indicating various visual and neurological conditions (Clark et al., 2019).

Until recently, the magnetic scleral search coil was considered the gold standard for recording eye movements (Collewijn et al., 1988). However, studies have shown that scleral coils, being invasive, can potentially harm the cornea even before any visual tasks (Irving et al., 2003). With technological advances, non-invasive video-based eye-tracking systems using infrared (IR), such as EyeLink (Van Der Geest & Frens, 2002), have become popular in research and have been shown to produce results comparable to the search coil method.

Despite the potential of eye trackers to provide reliable and quantitative evaluations of eye movements, their clinical application remains limited (Clark et al., 2019). Objective eye recording techniques are not widely used in clinical settings to monitor conditions affecting eye movements, such as ocular nerve palsy or brain injuries (Clark et al., 2019; Shafee, 2021). To ensure their utility in clinical diagnosis, the feasibility and accuracy of these instruments must be thoroughly assessed, as any deviation or inaccuracy in data recording could compromise their effectiveness.

This study aims to evaluate the performance of the Tobii Pro Fusion-120Hz in measuring saccadic peak velocity in a healthy population, with the results compared to data from the higher sampling rate EyeLink 1000 Plus, which has been validated for clinical use The normative data obtained can serve as a benchmark for assessing and monitoring patients with eye movements anomalies in clinical settings, despite the lower sampling rate of the Tobii Pro Fusion-120Hz.

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As no previous research has examined normative data for saccadic movements using this device, its accuracy for clinical applications has not yet been established.

MATERIALS AND METHODS

The study employed a cross-sectional design with convenience sampling. Participants were selected based on availability and meeting the inclusion criteria. This method was chosen to efficiently gather data from a specific population within a limited timeframe.

This study adhered to the Tenets of the Declaration of Helsinki for research involving human subjects and received ethical approval from the IIUM Research Ethics Committee (IREC 2023-KAHS/DOVS15). The number of participants in this study was determined based on previous eye movement recording (EMR) studies that have assessed eye trackers in healthy populations. These studies, such as those by (Huaman & Sharpe, 1993; Shafee, 2021; Yang & Kapoula, 2006), have shown that a smaller sample size is generally sufficient for evaluating the accuracy and performance of eye trackers in this context. Since the primary aim of this study was to assess the device's capability in measuring saccadic peak velocity rather than generalizing to a broader population, a large sample size was not required. Additionally, EMR studies typically focus on the reliability and performance of the technology within a controlled group, and the results from similar studies have been consistent with smaller sample sizes. Therefore, a formal sample size calculation was not deemed necessary for this study. The sample size chosen aligns with those used in prior research, where the goal was to establish initial performance benchmarks for the device rather than statistical power for hypothesis testing.

Participant

All participants underwent a comprehensive optometric examination before recruitment and fulfilled the following inclusion criteria; age between 18-23 years, normal ocular motility test (OMT) results, best-corrected visual acuity (VA) of 0.2 log MAR or better in both eyes (measured using ETDRS chart), no history of ocular trauma or brain injuries and no significant underlying ocular pathology or systemic disorder. The age group in our study was carefully controlled to match the demographics of the population from which the EyeLink normative values were derived. Specifically, we ensured that the age range of participants in our study aligned with that of the previous population, as saccadic eye movement performance is influenced by aging (Shafee, 2021; Abel et al., 1983). This control was implemented to minimize age-related differences and ensure consistency in saccadic peak velocity measurements, thereby enhancing the validity of our comparisons.

All included participants had myopia less than -6.00, as higher myopic corrections can affect accurate calibration at eccentric points (Shafee, 2021). Participants who were using rigid gas permeable (RGP) contact lenses were excluded from this study as RGP usage could lead to abnormal eye recording results, especially in horizontal eye movements at eccentric positions (Shafee, 2021).

Eye Tracker Setup

Saccadic movements were measured using the Tobii Pro Fusion-120Hz eye tracker. The eye tracker was mounted on a monitor positioned 60 cm from the participant, subtending a visual angle of 0.53 degrees. Data were recorded on an HP Pavilion laptop equipped with Tobii Pro Lab Software.

Procedure

Participants completed the eye tracking using Tobii Pro Fusion-120Hz with their best-corrected visual acuity, ensuring that any refractive errors were properly corrected during the eye tracking assessments. This approach was crucial to maintaining the accuracy of the saccadic measurements and ensuring that the visual acuity of all participants met the inclusion criteria of 0.2 logMAR or better. The remaining inclusion criteria were confirmed through standard clinical tests that do not involve direct eye contact, including OMT, cover test at distance and near, and history taking. The informed consent was obtained after confirming that the participants met the inclusion and exclusion criteria.

Participants were instructed to follow on-screen instructions while resting their head on a head and chin rest to ensure stability throughout the test. Calibration accuracy and precision thresholds were set at 0.5° and 0.2°, respectively. Participants who did not meet these thresholds were instructed to recalibrate.

A black cross target of size 0.25° appeared at the center of the screen for 1-3 seconds, then reappeared at ±10° horizontally from the center for 1-2 seconds. This setup prompted participants to rapidly move their eyes to the new target position and fixate on it, ensuring accurate measurement of visually triggered saccadic eye movements.

Each participant completed 24 saccadic trials binocularly, with an equal number of targets presented on both the left and right sides of the screen center. The entire

measurement, including the calibration process, took approximately 5 minutes per participant. Eye movements can be examined either binocularly or monocularly, depending on the study's objectives (Hooge et al., 2019). This study selected binocular recordings to accurately observe and analyze the interaction between both eyes and assess normative saccadic coordination in subjects with normal ocular motor function. While monocular recordings can minimize irritation, especially in studies involving invasive methods (Irving et al., 2003), binocular recordings were essential for a comprehensive evaluation of eye movement dynamics in this case.

Data Analysis

Data recorded by Tobii Pro Lab Software was transferred to Microsoft Excel 365 for filtering abnormal and extraneous data. After filtering, a pivot table was created to obtain the average mean of each saccadic peak velocity for all participants. The primary variable analysed was saccadic peak velocity. This study provides normative saccadic peak velocity data using video recordings from a lower sampling rate eye tracker. Saccadic peak velocity was chosen as the primary parameter because it has been shown to detect the onset of ocular movement dysfunction and to clearly track improvements over time, as demonstrated in previous research (Metz et al., 1970; Shafee, 2021).

Normality testing was conducted using the Shapiro-Wilk test, skewness, P-P plot, and histograms (Mishra et al., 2019). Based on these results, the data were considered normally distributed. A one-sample t-test was then conducted to compare the average mean peak velocity recorded by the Tobii Pro Fusion-120Hz with the mean data established from previous clinical study (Shafee, 2021).

The methodology employed—using a one-sample t-test to compare current data with established benchmarks—follows established practices in ocular motor research (Mack et al., 2017). This approach is justified given the need to compare new tools against reliable standards. The relevance of high-resolution tracking in clinical settings is further supported (Shafee, 2021), reinforcing the applicability of the Tobii Pro Fusion-120Hz for detailed ocular assessments.

Statistical Analysis

Statistical analysis was performed using SPSS version 23. The data's normality was checked, and a one-sample t-test was performed to compare the accuracy of saccadic peak velocity measurements from the lower sampling rate eye tracker with those obtained from a higher sampling rate eye tracker used in previous study (Shafee, 2021).

RESULTS

Participants in the study were healthy individuals aged 18-23 with normal ocular motility test results. All participants had a best-corrected visual acuity of 0.2 log MAR or better in both eyes and myopia of less than -6.00D. These criteria were set to ensure accurate calibration of the eye tracker, as ocular misalignment or high myopia could interfere with the results (Shafee, 2021).

One-Sample T-Test

A one-sample t-test was conducted to compare the average saccadic peak velocity recorded by the Tobii Pro Fusion-120Hz with the mean peak velocity data from the EyeLink 1000 Plus (Shafee, 2021). The one-sample t-test was used to compare the mean of saccadic peak velocity obtained with the Tobii Pro Fusion-120Hz eye tracker against a known value from the EyeLink 1000 Plus, which is a higher sampling rate device. This test is appropriate for assessing whether the mean saccadic peak velocity measured by the Tobii Pro Fusion-120Hz differs significantly from the established mean obtained from the EyeLink 1000 Plus (Mack et al., 2017).

The comparison was made with a known value (the mean from the EyeLink 1000 Plus) to determine if the observed data from the Tobii Pro Fusion-120Hz are consistent with or deviate from the established benchmark. The average saccadic peak velocity measured using the EyeLink 1000 Plus was 327 m/s, while the Tobii Pro Fusion-120Hz measured 323 m/s. These values reflect the performance of both eye trackers, demonstrating that the measurements from the latter are closely aligned with those of the former eye tracker. Table 1 shows that there was no significant difference in saccadic peak velocity measurements between the Tobii Pro Fusion-120Hz and the EyeLink 1000 Plus eye trackers ($p = 0.31$).

Table 1: One-sample T-test comparing saccadic peak velocity

Parameter	Test Value	Mean ±SD	t-value	df	Mean Difference	p-value
Saccade peak velocity (m/s)	327	323 ± 42.6	1.053	15	15.79	0.31

DISCUSSION

This study aims to evaluate the performance of the Tobii Pro Fusion-120Hz in measuring saccadic peak velocity in a healthy population, with the results compared to data from the higher sampling rate EyeLink 1000 Plus, which has been validated for clinical use. The findings confirm that the Tobii Pro Fusion-120Hz provides valid saccadic peak velocity measurements, comparable to those obtained with the EyeLink 1000 Plus, supporting its potential for clinical assessments. Previous study highlights the value of high-resolution tracking in detecting subtle eye movement abnormalities and monitoring recovery (Shafee, 2021), making the Tobii Pro Fusion-120Hz a valuable tool for similar clinical assessments. The efficacy of eye tracking in differentiating neurological disorders was further supported, emphasizing the role of precise tracking in clinical diagnostics (Marx et al., 2012). Eye trackers have been proven valuable in clinical settings due to their ability to provide precise and detailed measurements of ocular movements.

Additionally, research has shown that eye trackers can effectively identify and differentiate various eye movement disorders, such as nystagmus (Rosengren et al., 2020; Wong et al., 2006) and can be used to evaluate visual attention and cognitive processes (Katz et al., 2019). These applications underscore the potential of eye-tracking technology to enhance diagnostic accuracy and improve patient management in clinical practice.

However, it is acknowledged that the sampling strategy could be improved. Although this study focused on a specific demographic for consistency, limitations in sample size and diversity are recognized. For future research, it is recommended that a larger and more diverse sample be included to enhance the generalizability of the findings. Additionally, exploration of other saccadic parameters, such as saccadic latency and gain, is highly recommended to provide a more comprehensive assessment of the eye tracker's performance. These adjustments will help to strengthen the study's conclusions and offer more robust insights into its clinical applicability.

The Tobii Pro Fusion-120Hz eye tracker shows strong potential for clinical use, offering saccadic peak velocity measurements with accuracy comparable to the EyeLink 1000 Plus. This capability enhances its suitability for diagnosing and managing eye movement anomalies, supporting more precise and effective clinical evaluations.

CONCLUSION

The study demonstrates that the Tobii Pro Fusion eye tracker, operating at 120Hz, reliably measures saccadic peak velocity, with results closely aligning with those obtained from the higher sampling rate EyeLink 1000 Plus. However, the present study has limitations, including a small and specific sample. Future research should use a larger and more diverse sample and explore other saccadic parameters like latency and gain. These improvements will help confirm the Tobii Pro Fusion-120Hz's effectiveness in clinical settings for assessing and monitoring eye movement issues.

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