Investigation of the Relationship Between Smooth Pursuit Oculomotor Parameters Using a Novel Approach

Muhammad Uzair Latif[1], Min Hsu[1], Lan-Yuen Guo[1]
[1]Department of Sports Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan
Email: yuen@kmu.edu.tw

Summary

Smooth Pursuit Neck Torsion Test (SPNT) and Gain values assess sensory mechanisms in cervical oculomotor control, but results are inconclusive. This study analyzed correlations among oculomotor parameters: gain, angular error, latency, maximum correlation coefficient (xCorr max) between eye and visual target positions, and the lag when xCorr max occurs. Results indicated gain correlates significantly with angular error, lag, and Xcorr. Additionally, absolute lag is related to angular error and gain variability, highlighting its impact on the stability of eye movement tracking in the study.

Introduction

Eye movement mechanisms are influenced by cervical posture changes, particularly in proprioception. Therefore, eye movement performance can be used to evaluate the effect of cervical proprioception on sensory integration. The SPNT is critical for assessing smooth pursuit performance under different cervical positions. Currently, criteria for evaluation vary, and gain only reflects the tracking pattern rather than stability [1]. Therefore, it was necessary to develop additional parameters to achieve a more comprehensive assessment of pursuit stability. The maximum correlation coefficient (Xcorr max), the synchrony between eye and target movement, was used as an index to evaluate eye movement synchrony[2]. This study aims to thoroughly assess eye movement tracking integrity by examining the relationships among various oculomotor parameters instead of concentrating on just one tracking pattern.

Methods

Five healthy participants were secured with safety belts on Stewart platform with heads fixed. A 60 Hz infrared eye-tracking device (GP3, Gazepoint Research Inc. Vancouver, Canada) was used to measure and record ocular motor during smooth pursuit tasks. A 27-inch LCD monitor, positioned 68cm away, displayed a smooth pursuit task with a red dot moving horizontally at 50° amplitude and frequency 0.2Hz. For pursuit tasks, all participants underwent seven trials, each tracking ten cycles, with a 20-second rest interval between trials. Smooth pursuit data was collected by the Gazepoint analysis software. All the oculomotor parameters were processed using custom-written software in MATLAB (R2024b, MathWorks, Natick, MA, USA), including gain (ratio of eye velocity to target velocity), gain variability (fluctuations in gain across trials, reflecting tracking consistency), angular error (difference between eye and target position), latency (time delay between target and eye movement), cross-correlation (xCorr, representing signal similarity), and lag (time shift at which xCorr is maximized). We examined the Spearman correlation coefficient of oculomotor parameters. Two-sided tests were used to determine statistical significance, and the significance level was set at $p < 0.05$.

Results and Discussion

The results showed that gain was positively correlated with angular error (r = 0.65, p < 0.001) and xCorr (r = 0.41, p =0.014) but negatively correlated with lag (r =-0.33, p=0.050) and positively correlated with absolute lag value (r = 0.67, p < 0.001). Gain variability was positively correlated with angular error (r = 0.79, p<0.001) and negatively correlated with lag (r = -0.39, p = 0.02), as in Table 1. The findings indicated that predictive pursuit may enhance gain; however, this is accompanied by increased variability, which reflects fluctuations in anticipatory tracking control. The observed variability in increased gain suggests a degree of instability in prediction, resulting in pronounced fluctuations in lag and potential pursuit errors.

Table 1: Spearman Correlation Matrix for Oculomotor Parameters

Variables	Gain	Gain Std.	Angular error	Latency	xCorr	Lag	Lag (abs)
Gain	1	0.92**	0.65**	-0.13	0.41*	-0.53**	0.67**
Gain Std.		1	0.79**	-0.14	0.22	-0.39*	0.73**
Angular error			1	-0.11	0.03	-0.28	0.73**
Latency				1	0.11	-0.07	0.15
xCorr					1	-0.19	0.37*
Lag						1	-0.40*
Lag (abs)							1

Note: Spearman's correlation coefficients (rho) are reported.*p < 0.05, **p < 0.01 (two-tailed). Lag (abs) represents the absolute value of the lag.

Conclusions

These findings revealed the interrelationships among oculomotor pursuit parameters, where a change in one metric impacted overall performance. A comprehensive evaluation of smooth pursuit ability should integrate multiple parameters to complete a pursuit quality assessment.

Acknowledgments

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References

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