Changes in Youth Football Athletes' Oculomotor Task Metrics Across Three High School Seasons of Play

Duke BIOMEDICAL ENGINEERING

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Introduction

Traumatic Brain Injury: *"An alteration in brain function, or other evidence of brain pathology, caused by an external force."* [1]

- With 1.4 million emergency room visits and 52,000 deaths per year in the US, TBI is a major public health issue[2]
- Mild Traumatic Brain Injuries (mTBI) are estimated to account for 80-90% of all TBI cases[3]
  - However, there is a current lack of objective diagnostics[3] or unity in defining mTBI[4]
  - mTBI is commonly under-reported[5]

Football:

- Concussions exhibit immediate or transient TBI symptoms[5]
- Currently using multimodal tests to diagnose (e.g., SCAT5)[6]
  - Limited granularity/resolution for subtle differences seen in mTBI
  - Need quantitative measure of brain function alterations

Eye-Tracking Method:

- Eye-tracking assessments provides quantitative metrics associated with measures of oculomotor function[7]
  - Examines rapid eye movements (Saccades) during task performance

In this study, we assess for changes in baseline eye-tracking performance of 3 high-school American Football athletes conducting prosaccade and anti-saccade tasks over 4 yearly timepoints in their athletic careers.

- Any changes in saccadic metrics warrants future comparison between cohorts with different exposure to sub-concussive loading. Relative differences in oculomotor behavior aids quantification of mTBI risk.

Methods

- The participants of this study are three high school football athletes
- Tests were taken during the summer prior to fall football season using an Eyelink 1000 system (SR Research, Ottawa, Canada) at 1000 Hz.
- The three participants employed in this analysis are selected for possessing four yearly timepoints of eye tracking data
- Anti-saccade and prosaccade task Latency, Gain, and End-Gain values were taken in Prosaccade (n=28) and Anti-Saccade (n=25) Trials
- Trials were evaluated manually for tracking error metrics including noise and loss of tracking, with erroneous metrics invalidated from the study

Oculomotor Tasks: Prosaccade and Anti-Saccade

- **Prosaccade Task**: Eye is fixed to a dot stimulus. The stimulus disappears and reappears in a different position. The eye saccades to the new stimulus position.
- **Anti-saccade Task**: Eye is fixed to a dot stimulus. The stimulus disappears and reappears in a different position. The eye must resist a saccade to the stimulus and saccade to a position perceived as equal and opposite to the stimulus.

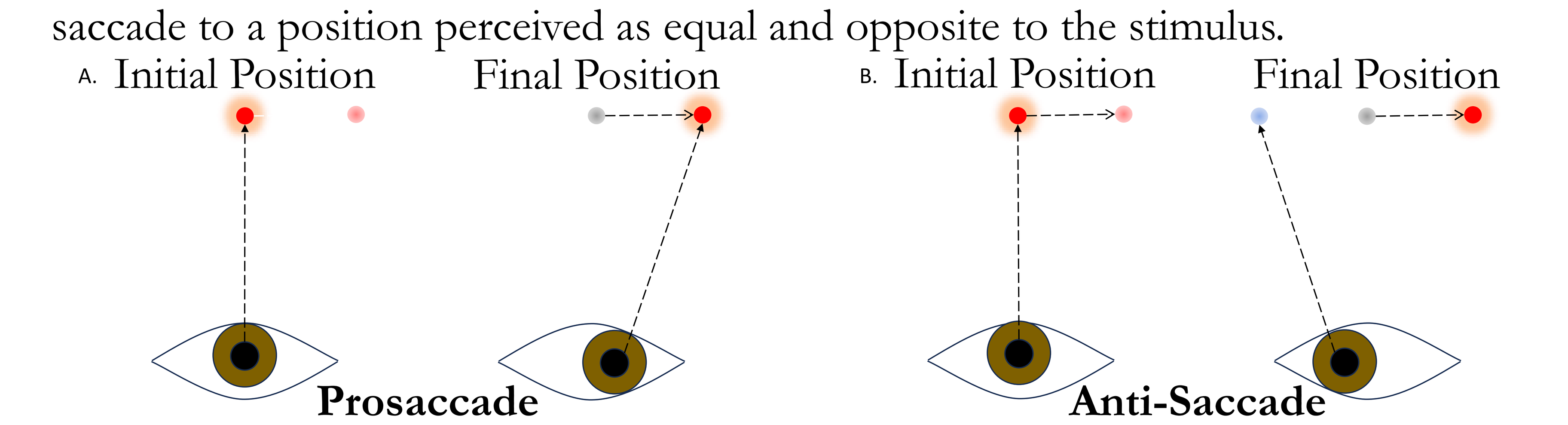

Figure 1. Illustration of the A) Prosaccade and B) Anti-Saccade task. Note that in the anti-saccade task, the eye resists following the target and saccades to an equidistant position.

Visualizing Oculomotor Tracking: Position Mapping

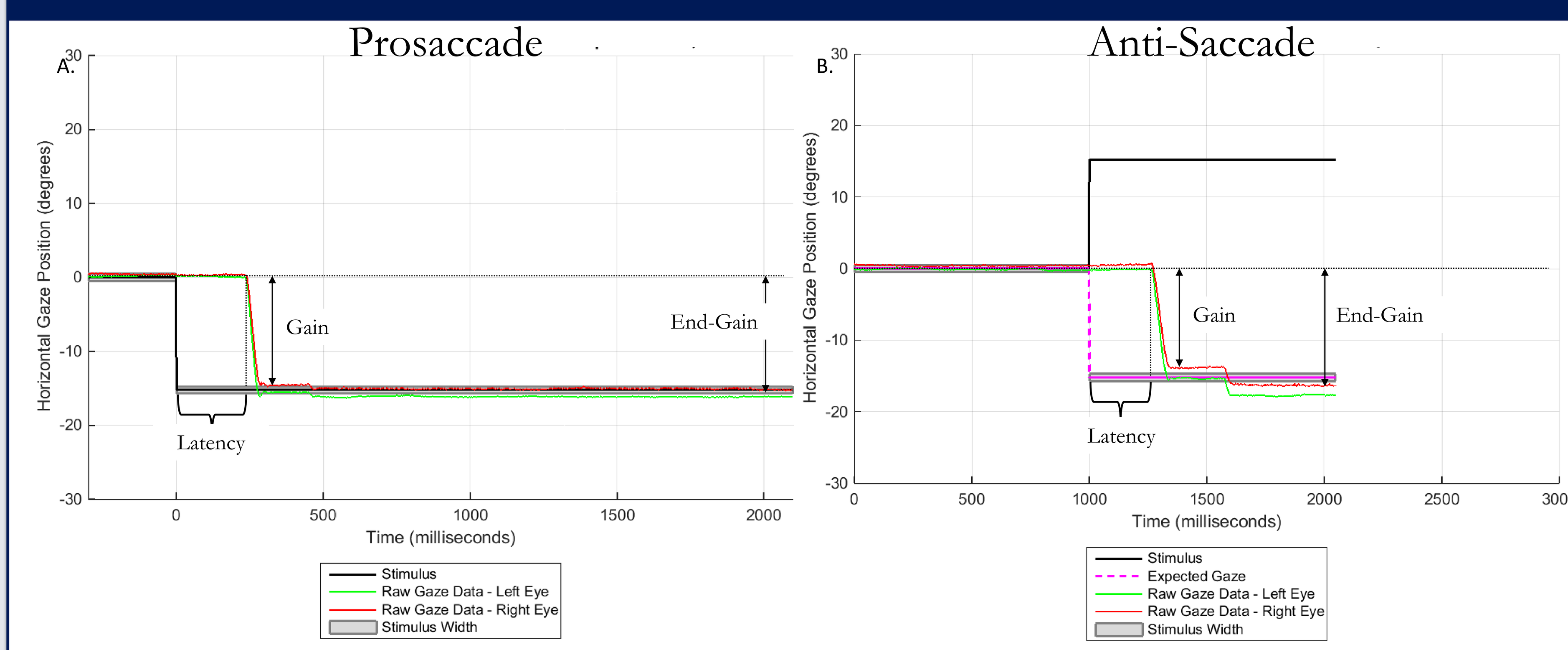

Figure 2. Examples of gaze position and eye-tracking during A) Prosaccade Task and B) Anti-Saccade Task

The following metrics are examined as indicators of oculomotor function:

- **Latency**: The time elapsed between stimulus position change and saccade initiation
- **Gain**: Initial saccade amplitude or distance (%) relative to stimulus position change
- **End-Gain**: Final saccade distance (%) relative to stimulus position change

Results

Table I. Prosaccade Task metrics. * is indicative of a significant difference of (P<0.05)

Pro-Saccade	Latency (ms)	Latency Std Dev	Gain (%)	Gain Std Dev	End-Gain (%)	End-Gain Std Dev
2015-2016	150.8	31.8	96.5	13.1	102.3	9.6
2016-2017	164.2	36.9	97.9	10.4	101.7	7.6
2017-2018	167.9	67.5	99.2	11.7	102.3	11.5
2018-2019	153.8	47.1	97.9	11.6	101.6	10.1

Table II. Anti-Saccade Task metrics. * is indicative of a significant difference of (P<0.05)

Anti-Saccade	Latency (ms)	Latency Std Dev	Gain (%)*	Gain Std Dev	End-Gain (%)*	End-Gain Std Dev
2015-2016	309.6	137.3	91.3	139.2	115.8	64.2
2016-2017	286.7	158.7	57.3	110.6	87.9	54.3
2017-2018	288.4	187.4	14.4	86.4	77.0	46.2
2018-2019	285.2	174.4	60.2	64.5	81.8	31.7

- Repeated Measures ANOVA was conducted in Minitab (Minitab LLC, State College, PA, USA) respective to Year and Subject for each metric within both tasks. Tukey's post-hoc comparison was performed to assess for where significant differences occurred.
- Differences between the first year and second year were seen in anti-saccade end-gain whereas differences between the first year and third year were seen in anti-saccade gain. This would imply that these changes occur over the span of 1 and two years respectively for these three athletes.

Discussion

- Gain and end gain decreases over high school football careers
- Hypo-metric anti-saccadic gain/end-gain in literature seen in patients with Parkinsonian[8] or ADHD[9], but are also observed in healthy populations[10]
- Relating saccadic measures to disease and injury provides insights into mechanism of both disease and injury
- Oculomotor function changes require future comparison of subject exposure to determine relationship in mTBI or sub-concussive loading

Limitations:

- This pilot study is limited by the sample size of 3 subjects. Further efforts will assess data from additional high school athletes.
- This study assumes a similar level of exposure among the 3 athletes. This study did not possess a non-exposure control group. Future comparisons with non-exposure groups warranted to determine if changes are related to sub-concussive loads in contact sport

Conclusions

- Three high school football athletes scored lower gain and end-gain magnitudes throughout their football career
- Significant differences with larger effect size than inter-subject variability found in anti-saccade gain and end-gain may be indicative of oculomotor changes over time
- These results provide comparative basis for oculomotor function changes in football players over 4 years.
- Future comparison with non-exposure controls may elucidate differences due to sub-concussive or mTBI loading
- Exposure/non-exposure differences in eye-tracking may provide insights into mTBI injury mechanism and risk.

Acknowledgements & References

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