

## INTRODUCTION

Concussion is a clinical diagnosis best made by a sports neurologist, with an estimated 1.6-3.8 million cases annually from various impacts. In professional sports, concussions significantly affect work disability, performance, and retirement, making accurate diagnoses crucial. Misdiagnosis leads to unnecessary loss of playing time, psychological burdens, and monetary costs. The complexity of concussions and the reluctance of athletes to report symptoms contribute to diagnostic challenges. Emerging tools like event-related potentials (ERPs), cognitive testing, and serum biomarkers show promise in concussion diagnosis but lack established clinical utility. Accurate diagnoses require stringent criteria and reliable evaluations, integrating neurophysiology and biomarkers to assess concussion effects and management effectively.

### Aims:

1. Include only those with a clinical diagnosis of definite concussion made by a Sports Neurologist at the Kutcher clinic using strict clinical criteria.
2. Ascertain alterations in the N100, P300 and N400 auditory ERP associated with the acute concussion specifically using Neurocatch technology.
3. Investigate the NF-L biomarker's response in those accurately diagnosed with concussion.
4. Examine changes in Cognivue the acute phase of concussion.
5. Connect the basic science to clinical application in order to elucidate if brain function, and serum biomarkers improve concurrently with the clinical neurological exam, thus establishing the value of ERP, NF-L, and Cognivue as clinical instruments.

### We hypothesized:

1. In the acute phase of concussion there will be alterations in serum biomarkers, ERP, and Cognivue
2. Additional clinical pathology such as migraine, anxiety, depression, and difficulty with sleep will be significant confounding variables.

## METHODS

### Concussion Diagnoses:

- A clinical exam and diagnosis of concussion was conducted at the Kutcher Clinic for Sports Neurology.
- The study utilized the unique Kutcher Clinic Impact Score to assess the likelihood of concussion from biomechanical forces.
- Only those diagnosed with a definite concussion were enrolled in the concussion group to ensure accurate diagnoses.
- We plan to collect data at three time points: within 24-48 hours of impact, 7-10 days post-impact, and six months post-impact.

### Measures:

- Cognitive performance was measured using Cognivue testing (Cahn-Hidalgo et al.).
- Event related potentials, namely the N100, P300 and N400 was acquired using the NeuroCatch technology by the Kutcher clinic team and analyzed in a similar fashion to previous work (29-31)
- Mood was measured using the PHQ9 and GAD questionnaires (Kroenke et al., Donker et al.).
- Sleep, Memory and Mood were self report metrics.

### Statistical Analysis:

- Data was analyzed in IBM SPSS (IBM, www.ibm.com/software/analytics/spss).

## ACKNOWLEDGMENTS



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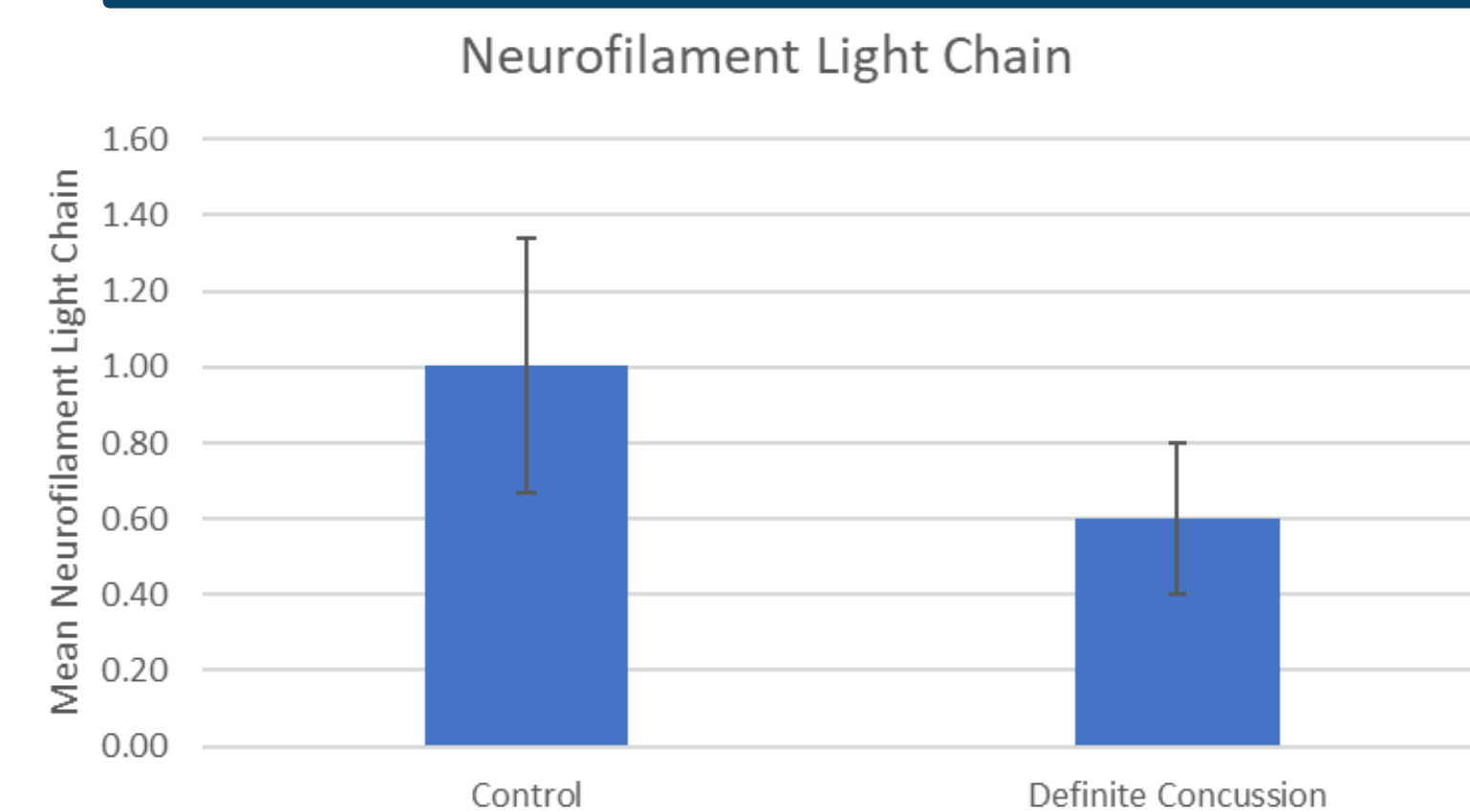
## Clinical Findings

|                                       | Control | Definite Concussion |                   | Control | Definite Concussion |
|---------------------------------------|---------|---------------------|-------------------|---------|---------------------|
|                                       | Mean    | Count               |                   | Mean    | Count               |
| Age                                   | 21      |                     |                   | 20      |                     |
| Sex                                   |         |                     |                   |         |                     |
| Female                                |         | 6                   | Female Concussion |         | 2                   |
| Male                                  |         | 5                   | Male              |         | 1                   |
| Mechanism                             |         |                     |                   |         |                     |
| KC1                                   |         | 3                   | KC1               |         | 0                   |
| KC2                                   |         | 5                   | KC2               |         | 0                   |
| KC3                                   |         | 0                   | KC3               |         | 3                   |
| Days from impact to testing           | 60      |                     |                   | 1       |                     |
| Symptom Duration Prior To Appointment | 53      |                     |                   | 1       |                     |

|                 | Control | Definite Concussion |                 | Control | Definite Concussion |
|-----------------|---------|---------------------|-----------------|---------|---------------------|
|                 | Count   | Count               |                 | Count   | Count               |
| LOC             |         |                     | PHQ9 Concussion |         |                     |
| No              | 11      | 3                   | Yes             | 5       | 0                   |
| Yes             | 0       | 0                   | PHQ9            |         |                     |
| Amnesia         |         |                     | No              | 2       | 0                   |
| No              | 11      | 1                   | Yes             | 3       | 0                   |
| Yes             | 0       | 2                   | PHQ9 Concussion |         |                     |
| Headache        |         |                     | No              | 2       | 0                   |
| No              | 4       | 0                   | Yes             | 6       | 3                   |
| Yes             | 7       | 3                   | PHQ9            |         |                     |
| Photophobia     |         |                     | No              | 6       | 3                   |
| No              | 4       | 0                   | Yes             | 5       | 0                   |
| Yes             | 7       | 3                   | PHQ9 Concussion |         |                     |
| Phonophobia     |         |                     | No              | 10      | 3                   |
| No              | 6       | 1                   | Yes             | 1       | 0                   |
| Yes             | 5       | 2                   | PHQ9            |         |                     |
| Nausea          |         |                     | No              | 10      | 3                   |
| No              | 5       | 1                   | Yes             | 1       | 0                   |
| Yes             | 6       | 2                   | PHQ9 Concussion |         |                     |
| Cervical Injury |         |                     | No              | 6       | 0                   |
| No              | 5       | 0                   | Yes             | 5       | 3                   |
| Yes             | 6       | 3                   | PHQ9            |         |                     |
| Mood            |         |                     | No              | 10      | 2                   |
| No              | 7       | 0                   | Yes             | 1       | 1                   |
| Yes             | 4       | 3                   | PHQ9 Concussion |         |                     |
| Sleep           |         |                     | No              | 7       | 2                   |
| No              | 9       | 1                   | Yes             | 5       | 0                   |
| Yes             | 2       | 2                   | PHQ9            |         |                     |
| Cognivue        |         |                     | No              | 7       | 2                   |
| No              | 6       | 2                   | Yes             | 2       | 2                   |
| Yes             | 5       | 1                   | GAD-7           |         |                     |
| Vestibular      |         |                     | No              | 2       | 2                   |
| No              | 9       | 3                   | Yes             | 2       | 0                   |
| Yes             | 2       | 0                   |                 |         |                     |

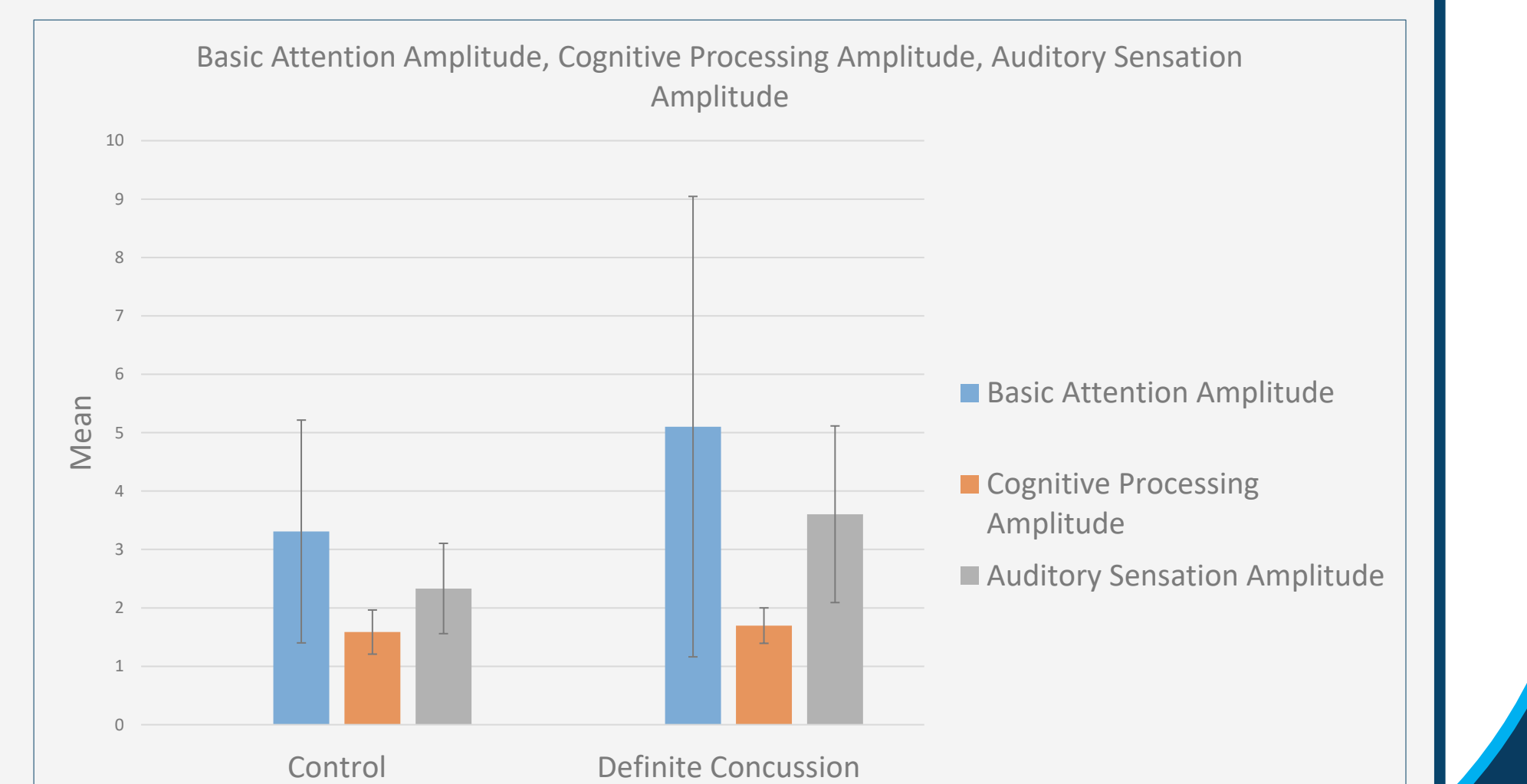
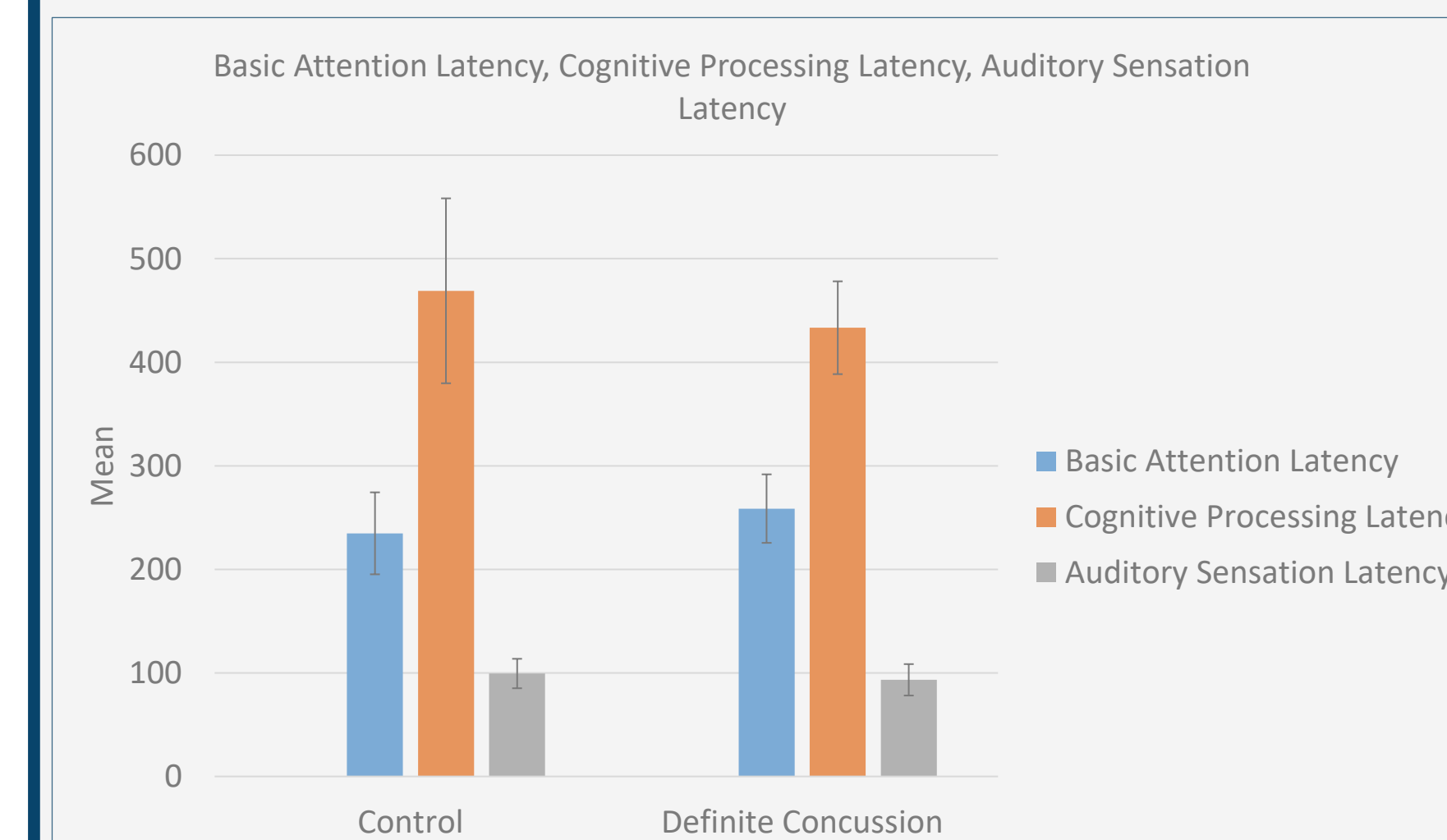
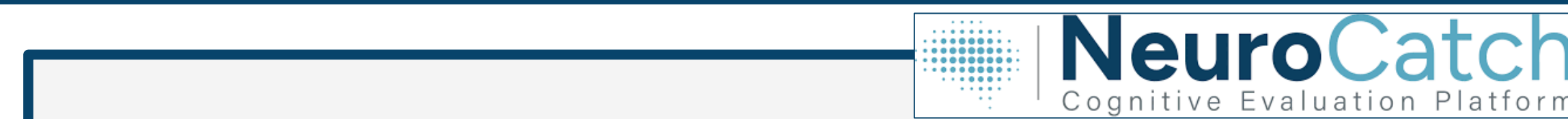
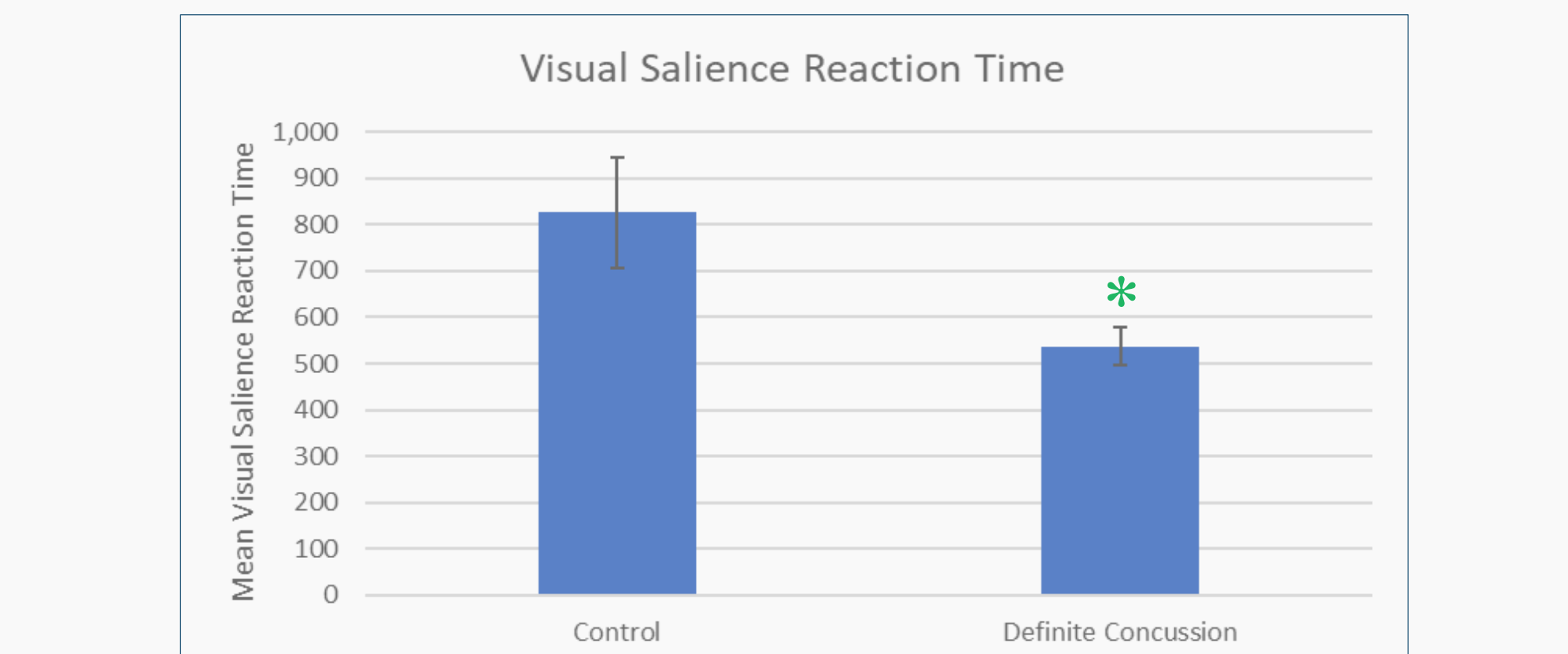
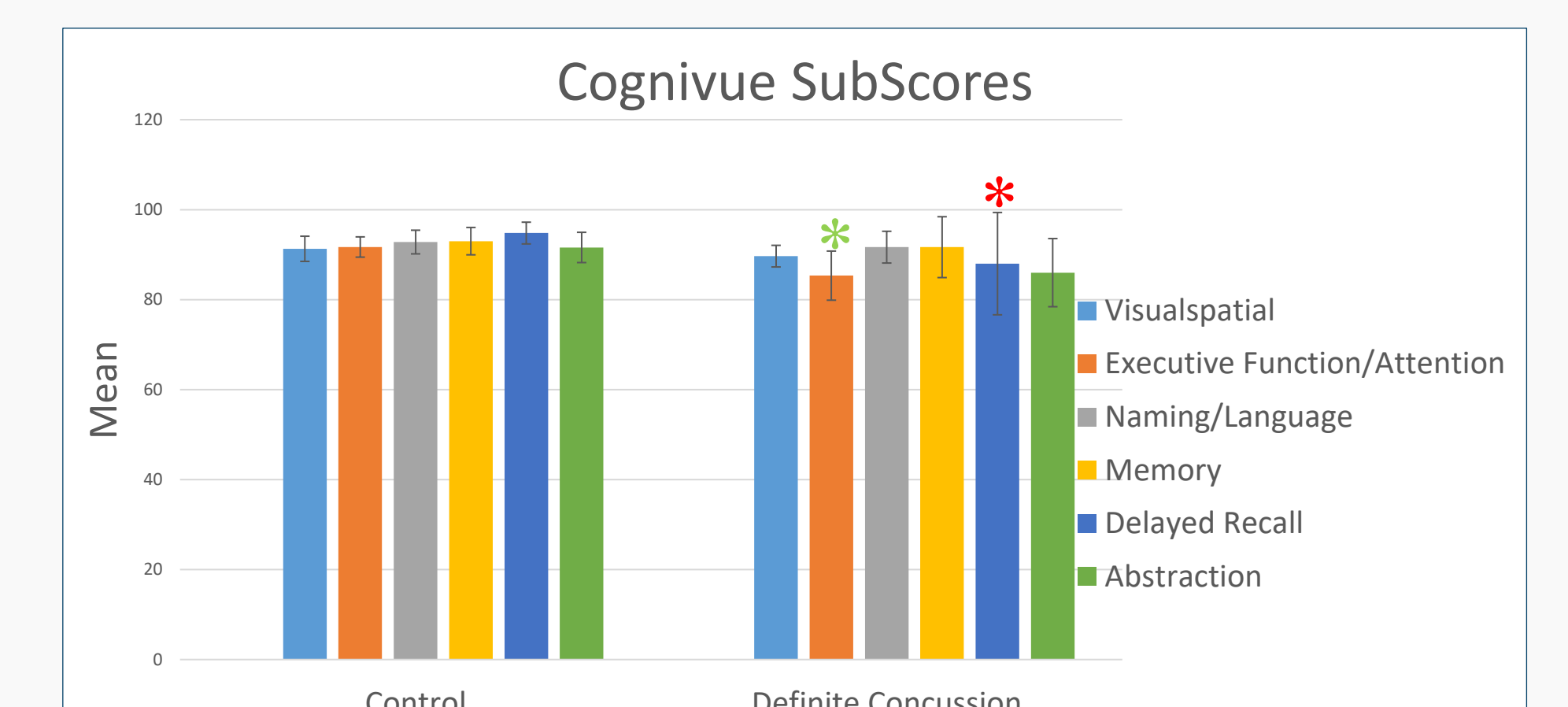
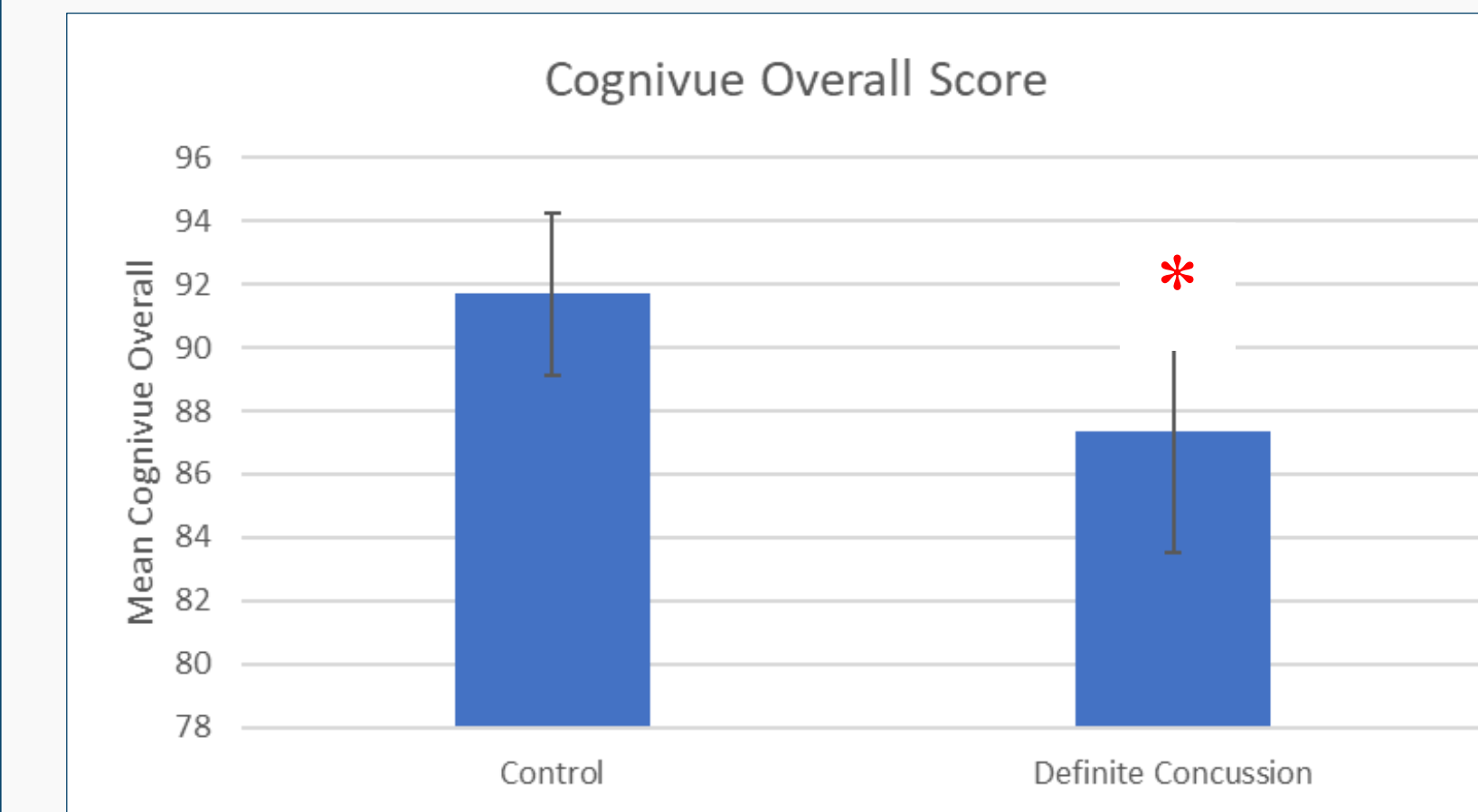
## Serum Neurofilament Light Chain



\* Indicates significant difference at p<0.05

\* Indicates significant difference at p<0.1

## RESULTS



## DISCUSSION

### HYPOTHESES:

1. In the acute phase of concussion Neurofilament light chain will be elevated compared to controls.
2. In the acute phase of concussion there will be alterations in ERP (Neurocatch) compared to controls.
3. In the acute phase of concussion Cognivue scores will be lower compared to controls.
4. Additional clinical pathology such as migraine, anxiety, depression, cervical strain and difficulty with sleep will be significant confounding variables.

### FINDINGS:

- Those with acute concussion did not have elevated Serum Neurofilament Light Chain.
- There was a trend for increased Basic attention and Auditory sensation Amplitude.
- Cognivue Score, reaction time, executive function, and delayed recall were different between groups.
- Abnormalities in Neurocatch were found in those with migraine and cervical strain.

## CONCLUSION

Overall, this data underscores the complexity of accurately diagnosing concussions and the necessity of considering a wide range of factors that may influence cognitive and neurophysiological assessments.

## FUTURE DIRECTIONS

- The Thompson-Kutcher Formula establishes new standards for the clinical investigation of novel technologies, inclusion criteria for concussion research, and clinical care of athletes.
- At the completion of this study, we aim to determine the clinical utility of ERP (Neurocatch), serum biomarkers (NF-L), Cognivue in diagnosing and managing acute concussion, and how these metrics correlate with clinical exams.
- This knowledge will validate these tools and enhance our understanding of the neural bases of concussion, utilizing strict diagnostic criteria.