NEAR POINT OF FIXATION DISPARITY (NPFD) AND ITS ASSOCIATION WITH CONCUSSIVE INJURY

by

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EVOLUTION OF OPTOMETRIC PRACTICE EXPECTATIONS:
THE RESULTS OF A SURVEY OF PRACTITIONERS

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ABSTRACT

Background: The Rinkside Concussion Investigator Group was formed to investigate the protocol for removing an athlete from play when a potentially concussive injury has occurred[1]. The Near Point of Fixation Disparity (NPFD) test is an assessment that has shown promise in the area of concussion determination[2]. This research was seeking to determine normative values for the NPFD test. It was designed to supplement ongoing investigations of the use of the NPFD test with the goal of determining if the test can be used for rink/sideline concussion screenings during sporting events. ***Methods:*** The NPFD test requires the subject to view a card with polarized nonius lines while wearing polarized glasses. While focusing on the central E target, the near point of fixation disparity card is moved slowly inward toward the subject's nose. As the target approaches the subject, they report when the vertical nonius lines become horizontally misaligned. The distance, measured from the spectacle plane to the card, at which this misalignment occurs indicates the NPFD breakpoint. As the target is moved back toward the start point, the distance at which the lines become re-aligned is recorded as the recovery point[1,3]. ***Results:*** The goal of this study was to begin to establish a range of NPFD normal values. Studies have shown that a reduced near point of fixation disparity is associated with history of a concussion[3]. The immediate effect of a concussion on near point of fixation disparity breakpoint and recovery has not yet been researched. ***Conclusions:*** Establishing normal findings for the NPFD test is an important step in

determining if this test can be used on athletes who have had a suspected injury. This research and further research using this data will be beneficial to the sports community in providing a quick, easy and reliable assessment to make return-to-play decisions.

ACKNOWLEDGMENTS

A special thanks to our advisor, Dr. Alison Jenerou, OD, for her extensive help and guidance throughout this project.

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CHAPTER 1

INTRODUCTION

"Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces"[4]. These forces are a result of rapid linear and rotational acceleration and deceleration within the brain[5]. Concussions have been referred to as mild traumatic brain injuries that involve a cellular process of disrupted ionic balance along with normal metabolism; this increased energy demand is coupled with decreased cerebral blood flow and mitochondrial dysfunction[3]. Because of this process, there is vulnerability after one sustains a concussion, and a repeat brain injury prior to complete recovery further disrupts cellular metabolism, resulting in more significant cognitive deficits in areas such as attention and memory[3]. Additionally, oculomotor dysfunctions are common after concussive injuries. The most common of these is convergence insufficiency[6].

There are between 1.6-3.8 million sports-related concussions in the United States each year, and difficulty arises when determining whether it is safe for these athletes to be reintegrated into the game[3,7]. The increased risk of serious consequences with repeated head injury makes research in this area incredibly important[7,8]. Concussive injuries may be associated with a vast array of potential symptoms including, but not limited to: headache, nausea, vomiting, dizziness, fatigue, blurred vision and difficulty with concentration[9,10,11]. Although concussive injury is often coupled with significant

symptoms, these symptoms should not be used in isolation with return-to-play considerations, as even asymptomatic patients are not always fully recovered[9,10]. Asymptomatic patients may still have a diminished ability to perform attention-based tasks and may also have a decreased reaction time[9,10]. It has been found that certain variables may be associated with a longer recovery time, including a history of a previous concussion, the presence of retrograde or anterograde amnesia, concussions at a younger age, and concussive injury in females[9].

Studies using collegiate athletes have shown a positive correlation between previous concussive injury and subsequent concussions during the season. Athletes who had sustained three or more concussive injuries were three times more likely to have an additional concussion than players who had no history of concussion[7]. Guskiewicz's study further reinforced the aforementioned finding that recovery time increases in athletes who have had multiple concussions[7]. Research by Poltavski and Biberdorf revealed that a history of a concussion increases the risk of a repeat concussive injury by 2-5.8 times[3]. These statistics indicate that subsequent head injuries are certainly an area of concern in athletics.

Screening protocols for a potentially concussive injury may prove to be incredibly beneficial when determining whether it is safe for an athlete to continue play during a game. Data collection to establish normative values for return-to-play determination is imperative in order to move forward and allow for utilization of these methods for real-world sideline concussion screenings. Questionnaires and thorough documentation of an athlete's concussion history can be beneficial as well, but multiple screening methods may allow for an increased rate of concussion detection. A comprehensive and systematic

approach including a variety of screening techniques, questionnaires and thorough documentation would assist in the process of treatment and management of athletes[4].

The near point of fixation disparity (NPFD) test is one tool that can be used in concussion assessment. Research has been conducted to determine the efficacy of various tests, such as this one, in the detection of a concussive injury. A study by Biberdorf and Poltavski found five variables that were significantly different between concussed and non-concussed individuals. The included tests to determine these variables were accommodative facility, mean comprehension rate and duration of eye fixations on the Visagraph test, total score for one part of an ADHD questionnaire and the NPFD test. Their study showed that receded NPFD values were predictive of a previous concussive injury; the results of the study indicated that an individual with a NPFD value greater than or equal to 15cm was much more likely to have sustained a concussion than an individual with a NPFD of less than 15cm. In fact, this study stated that a receded NPFD of 15cm or more indicated that the individual was 10.72 times more likely to have sustained a concussive injury, when combined with data from the other four previously mentioned concussion prediction tests[3].

While The NPFD test has shown value the area of concussion assessment; this test has a number of additional benefits. It is relatively inexpensive, quick, and easy to administer[3]. Ultimately, the goal is to provide protocols to better determine whether an athlete can be safely reintegrated into play.

CHAPTER 2

METHODS

Study Design: Near point of fixation disparity (NPFD) involves disruption of binocular fusion to an incoming near point target, which reflects a conflict between vergence and accommodation within Panum's area[1]. The basis for this research involved determining normative values for NPFD.

Participants: Patrons scheduled at the University Eye Center between the ages of 10 and 25 years old were invited to participate in the research. Each participant, and when appropriate, their guardian signed the consent to participate. Patients with binocular or oculomotor abnormalities or those who failed to understand the test were not selected to participate.

Data Collection: The Nearpoint of Fixation Disparity test was measured by placing the near fixation disparity card at 50 cm from the subject. The subject was wearing their habitual glasses or contact lenses and polarized glasses. The patient was asked to maintain fixation on the central 'E' target while paying attention to the vertical nonius lines above and below the 'E'. The patient was asked if both vertical lines were perfectly aligned with each other. It was noted on the record if the upper or lower arrow disappeared or if they were not perfectly aligned or were moving. If the vertical lines were initially aligned, the NPFD target was slowly moved toward the participant at a rate of 1-2 cm per second and the patient was asked to identify the point at which the vertical

arrows began to slide or slip so that they were no longer perfectly aligned and remained misaligned for at least 2 seconds. This value, known as the break point, was mentally noted. The NPFD target was slowly moved in the opposite direction, away from the patient, and the patient was asked to report when the vertical lines became perfectly realigned again. The distance value, the recovery point, was noted when the patient reported this realignment. This process was repeated two more times with the patient reporting misalignment of the vertical lines (break point) along with realignment of the vertical lines (recovery point). The break and recovery points for each trial were recorded on the form.

Data Analysis: The results of this study have been analyzed in order to determine normative values for this test. For analysis purposes, participants were placed into two groups by age, ages 10-17 and 18-25. Norms were analyzed by age, gender, and total subjects.

CHAPTER 3

RESULTS

There were 7 participants in this study ranging from age 10-25. Three of them were male and 4 were female. One of the participants had a history of concussion. This information is portrayed in Table 1.

Age Range	10-25
Average Age	20
Male	3
Female	4
History of Concussion	1
Number of Participants Age 10-17	3
Number of Participants Age 18-25	4

Table 1. Gender, Age and Concussion history of Participants

Two of the participants reported the nonius lines to be misaligned at the start of the test, and no break and recovery values were recorded. For the others, the break point

ranged from 0-20 cm with an average of 8.20 cm. The median number was 7 cm and mode was 7 cm. The recovery point ranged from 0-28 cm with an average of 12 cm. The median recovery was 11 cm and mode was 0 cm. The recovery point was on average 4.75 cm further away from an individual's break point. The average male break point and recovery point was 3.33 cm and 5 cm respectively, compared to the average female break and recovery point of 11.44 cm and 16.67 cm, respectively. The average break and recovery point of participant who had a history of a concussion is 6.67 cm and 10 cm, which for this individual was comparatively less than the overall average of 8.20 cm and 12 cm. For age analysis, the participant's results were divided into 2 groups. Participants aged 10-17 had an average break and recovery point of 8.11cm and 12 cm, while the participants aged 18-25 had an average of 8.33 cm and 12 cm. These results are displayed in Table 2.

Break Point Range	0-20 cm
Break Point Average	8.20 cm
Median Break Point	7 cm
Mode Break Point	7 cm
Recovery Point Range	0-28 cm
Recovery Point Average	12 cm
Median Recovery Point	11 cm
Mode Recovery Point	0 cm
Average Difference between Break and Recovery point	4.75 cm

Average Male Break and Recovery Point	3.33 cm/5 cm
Average Female Break and Recovery Point	11.44 cm/16.67 cm
Average Break and Recovery of participants with history of concussion	6.67 cm/10 cm
Average Break and Recovery of Participants aged 10-17	8.11 cm/12 cm
Average Break and Recovery of Participants aged 18-25	8.33 cm/12 cm

Table 2. Table of Results

CHAPTER 4

DISCUSSION

The results of our study only begin to establish a range of normal findings. When these values are better established, values that fall outside can be considered abnormal. Research indicates concussion victims have higher values of break and recovery. As previously mentioned, one study found 15 cm to be the cut-off value that differentiated participants that were more likely to have had a concussion at some point in their life[3]. The one participant in our study had a break and recovery point below this value and the average value of our study of 8.20 cm. The criteria may have to be different for different groups based on age and gender. Although our data is minimal, our results indicate there may be a difference in the average findings for females versus males.

Study Limitations*:* Our study only begins to evaluate normative values for the NPFD test. Limitations in participant recruitment, investigator availability, and location inhibited out ability to collect sufficient data to perform an adequate analysis. To more effectively collect this data, future researchers should consider multiple investigators and locations collecting data over a much longer period of time. A much larger sample size is needed to validate normal findings for the NPFD. Another limitation to our study is that increased NPFD break and recovery indicates problems with the binocular vision system, which is not specific to concussions. This test will not be effective for participants with pre-existing or non-related binocular vision problems. Also, our data gives no

information regarding changes to NPFD immediately after sustaining a concussion, and how the NPFD changes in relation to the time of the concussive event.

Other testing methods for determination of concussive injury include the King-Devick Test, Optokinetic Nystagmus (OKN) Symptom Test, repeated near point of convergence (rNPC) Test, PLR-200 pupillometry and the FixTrain Anti-Saccade Test in addition to a number of non-vision related tests.[3]

Vision related tests have previously been shown to be particularly useful in detecting concussions. Numerous studies show that oculomotor problems occur in the majority of patients following a traumatic brain injury, with ranges from 50-90%. These problems include primarily convergence insufficiency, accommodative insufficiency and saccadic deficiencies[3]. The near point of fixation disparity test has been reported to be more sensitive to the oculomotor problems related with concussive events than other means of testing because it combines the demands of accommodation and vergence. A problem in either of these two systems can manifest as higher break and recovery point[3].

In the article Screening for Lifetime Concussion in Athletes: Importance of Oculomotor Measures, Poltavski and Biberdorf explain that "the traditional NPC break point measures the loss of binocularity that occurs outside of Panum's area while the NPFD break point represents a disruption of binocularity within Panum's area that is occurring much sooner than the NPC break point as one approaches the edge of one's fusion limit." This indicates that at the NPFD break point, a participant is not yet experiencing true diplopia, but is no longer able to maintain accurate ocular alignment. This allows examiners to detect alignment disparities that would not be detected with a

traditional near point of convergence test. It is our hope that this test can contribute to return to play decisions and prevent the serious damage associated with a repeat injury.

Our study was a starting point in further establishing the usefulness of the near point of fixation disparity test in determining whether or not to remove an athlete from play, with the ultimate goal of avoiding subsequent injuries. The benefits of the NPFD test are that it is more sensitive to oculomotor conditions related to a concussive event, it requires minimal equipment, and it takes only moments to perform. Additionally, the test administrator requires minimal training to be able to perform a valid test. Determining normative values is an essential step in the ongoing research of the Near Point of Fixation Disparity test and how it can be used to help ensure the safety of all athletes.

CHAPTER 5

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APPENDIX A.

IRB APPROVAL LETTER

Ferris State University

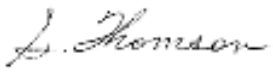
Institutional Review Board (FSU - IRB)
Office of Academic Research
Ferris State University
1201 S. State Street-CSS 310 H
Big Rapids, MI 49307
(231) 591-2553
IRB@ferris.edu

To: Dr. Alison Jenerou, Megan Szarkowski and Angela Rossman
From: Dr. Stephanie Thomson, IRB Chair
Re: IRB Application #140911 *(Near Point of Fixation Disparity (NPFD) and its association with Concussive Injury)*
Date: December 3, 2014

The Ferris State University Institutional Review Board (IRB) has reviewed your application for using human subjects in the study, *"Near Point of Fixation Disparity (NPFD) and its association with Concussive Injury"* (#140911) and has determined that it meets Federal Regulation category, *Expedited –category 2G/2F*. This approval has an expiration date of one year from the date of this letter. **As such, you may collect data according to procedures in your application until December 3, 2015.** It is your obligation to inform the IRB of any changes in your research protocol that would substantially alter the methods and procedures reviewed and approved by the IRB in this application. Your application has been assigned a project number (#140911), which you should refer to in future correspondence involving the same research procedure.

We also wish to inform researchers that the IRB requires follow-up reports for all research protocols as mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) for using human subjects in research. We will send a reminder to complete either the Final Report Form or the Extension Request Form to apply for a study continuation. Both forms are available on the IRB homepage. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,



Ferris State University Institutional Review Board
Office of Academic Research, Academic Affairs

FERRIS STATE UNIVERSITY

Institutional Review Board for Human Subjects in Research

Office of Academic Research, 220 Ferris Drive, PHR 308 · Big Rapids, MI 49307

Date: February 19, 2015

To: Dr. Alison Jenerou, Megan Szarkowski and Angela Rossman

From: Dr. Stephanie Thomson, IRB Chair

Re: IRB Application #140911 *(Near Point of Fixation Disparity (NPFD) and its association with Concussion Injury)*

The Ferris State University Institutional Review Board (IRB) has reviewed and approved your request for revision to continue using human subjects in the study, *"Near Point of Fixation Disparity (NPFD) and its association with Concussion Injury"* (#140911). This approval has an expiration date of one year from the date of this letter. **As such, you may collect data according to the procedures outlined until February 19, 2016.**

Your project will continue to be subject to the research protocols as mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) for using human subjects in research. It is your obligation to inform the IRB of any changes in your research protocol that would substantially alter the methods and procedures reviewed and approved by the IRB in your application. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,

S. Thomson

Ferris State University Institutional Review Board