

Background

- There is little research regarding the relationship between Near Point of Convergence (NPC) and Exercise Tolerance
- Exercise Tolerance can be tested in a clinical setting with a progressive exercise protocol¹

ARP Step	Exercise Intensity	Heart Rate Zone (bpm)	Time (min)
Step 1	Light	100-120	10-12
Step 2	Moderate	120-140	12-15
Step 3	Vigorous	140-160	15-18
Step 4	Maximal	160-180	20-25
Step 5	Maximal w/ Multidirectional Movement	160-180	30-45

Table 1: 5 Step Active Rehab Protocol

- Once patient clears ARP Step 5, they are cleared to fully participate in non-contact and low risk sports with multi-directional movement
- NPC is a quick and easy biomarker for determining Convergence Insufficiency²
- NPC values ≤ 8 cm are considered normal
- NPC values ≥ 9 cm are considered abnormal

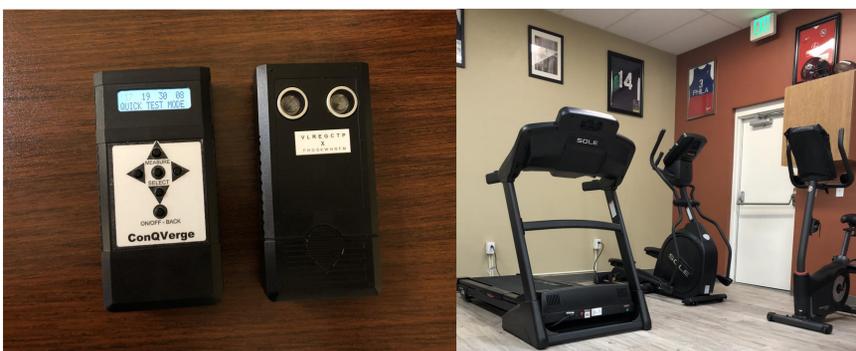


Figure 1: Ultrasonic device with on board microprocessor (Left), and exercise equip used for ARP

Purpose

To use NPC measurements as a clinical predictor for exercise tolerance in patients with post-concussion syndrome (PCS).

Hypotheses

A normal NPC, 8 cm or less, implies a high exercise tolerance while an increasing abnormal NPC will correlate with an increasing exercise intolerance

Materials and Study Design

- Retrospective Cohort Chart Review
- A total of 120 patients over 402 clinical visits were included in the study.
- All patients were seen between 11/17/17 and 4/30/19
- Clinical visits occurred 200 days or fewer after injury
- All patients were between the ages of 12-18
- NPC was measured with a digital ultrasonic device that included an on-board microprocessor accompanied with concussion specialist assessment upon each visit

Results

ARP Step	Total Visits	NPC Mean (cm)	P Value
Step 1	70	16.27 \pm 1.49	<.00001
Step 2	68	15.99 \pm 1.39	<.00001
Step 3	60	12.63 \pm 1.71	<.00001
Step 4	78	9.72 \pm 1.04	0.00071
Step 5	126	8.51 \pm 0.69	0.074

Table 2: Represents the average measured NPC at each ARP Step. The P-Value compares the NPC average to the normal NPC Value, 8cm, at the 5% significance level

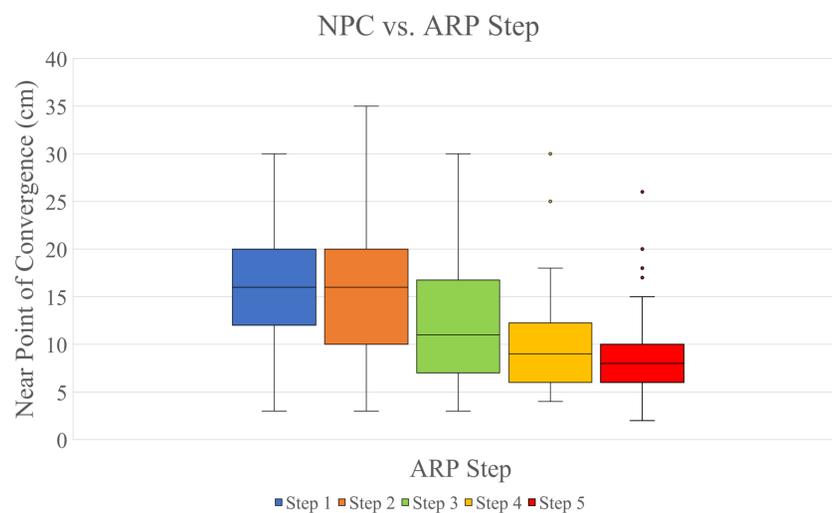


Figure 1: Box and Whisker Plot for NPC measurement vs. ARP Step. Outliers represented as dots Associated with Table 1

ARP Step	Percentage of visits with NPC ≤ 8 cm	Percentage of visits with NPC ≥ 9 cm
Step 1	10	90
Step 2	14.71	85.29
Step 3	33.33	66.67
Step 4	47.44	52.56
Step 5	63.49	36.51

Table 3: Displays the percent of clinic visits with an NPC ≥ 8 cm or ≤ 9 cm at each ARP Step.

Percentage of Visits with NPC 8 cm or less or 9 cm or more at each ARP Step

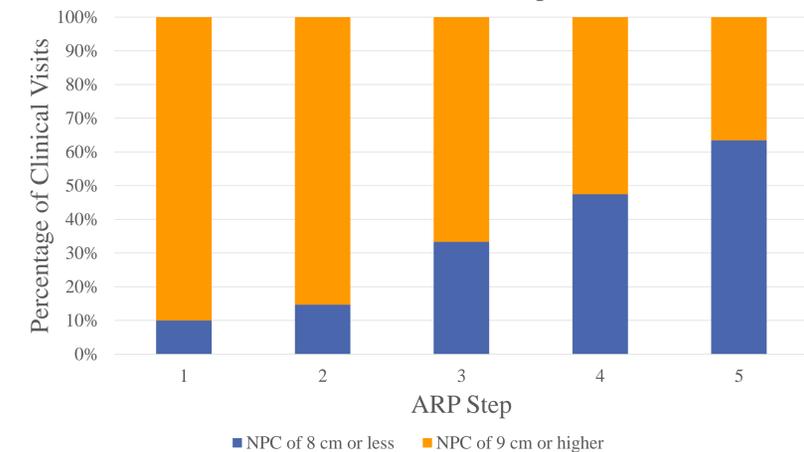


Figure 2: Stacked Column Graph displaying the proportions of clinical visits of either NPC ≤ 8 cm or NPC ≥ 9 cm at each ARP Step. Associated with Table 2

ARP Steps Compared	P Value
1 to 5	<.00001
2 to 5	<.00001
3 to 5	.000058
4 to 5	0.01213

Table 4: Pooled Proportions test to compare the proportions of clinical visits ≤ 8 cm between ARP Steps 1, 2, 3, or 4 and ARP Step 5

Conclusions

- ARP step was observed to have a negative correlation with NPC
- Average NPC for ARP Steps 1, 2, 3, and 4 all were significantly greater than the normal NPC value of 8 cm, see Table 1.
- There is significantly higher proportion of patients in the ARP Step 5 level with ≤ 8 cm NPC compared to ARP Step 1, 2, 3, and 4
- The results suggest that an increasing abnormal NPC will translate to a lower ARP Step while a patient with a ≤ 8 cm NPC can complete ARP Step 5 successfully

Significance

The rapidly and easily performed NPC oculomotor test can be used as a clinical predictor for exercise tolerance and help guide what ARP step may be most appropriate for concussed patients.

References

- Baker JG, et al. Return to Full Functioning after Graded Exercise Assessment and Progressive Exercise Treatment Post Concussion Syndrome. *Rehabilitation Research and Practice*. 2012;2012.
- DuPrey KM, Webner D, Lyons A, Kucuk CH, Ellis JT, Cronholm PF. Convergence insufficiency identifies athletes at risk of prolonged recovery from sport-related concussion. *Am J Sports Med*. 2017;45(10):2388-2393.