Reaction Time in Anterior Cruciate Ligament Reconstruction Individuals Under Cognitive Load

Sahaj Sapovadia, Jeffrey Turner, Courtney Chaaban, Darin Padua

Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, NC

BACKGROUND

Following injury to the anterior cruciate ligament (ACL) and subsequent ACL reconstruction (ACLR), patients undergo a period of rehabilitation that often concludes with a return to sport (RTS) testing. RTS testing has been historically structured around time after surgery and sport relevance.[1] In the context of actual sport, the individual is constantly undergoing motor challenges while under cognitive load. For example, decision making and divided attention between multiple tasks have been shown to change lower limb biomechanics such as reduced knee flexion at initial contact, increased vertical ground reaction force, and reduced stability during landing and cutting.[2] Cognitive load has not yet been implemented widely into RTS testing. Exploring the effects of implementing cognitive load on a common RTS metric like reaction time can better inform RTS criterion for passing. The terms neurocognitive and dual task conditions will be used interchangeably in this poster.

PURPOSE

Compare reaction times under neurocognitive conditions versus regular conditions and distinguish the differences in reaction time between individuals who underwent ACLR and healthy controls.

METHODS

This study included 28 participants (14 males and 14 females; age: 19.97 ± 4.01), 16 of which had undergone ACLR. Data collection was split between physical tasks and Senaptec sensory tests.

Physical Tasks:

- Regular Trials
  - Participant waits for light 2 to turn green
  - When light 2 turns green, participant initiates task, triggering laser sensor; reaction time is recorded
- Neurocognitive Trials:
  - Participant waits for light 1 or light 3 to turn a given “go” color.
  - When light 1 or light 3 turns “go” color, participant initiates task, triggering laser sensor; reaction time is recorded.
  - Initiation of task also triggers light 2 to flash a preset sequence of 3 colors, which the participant is then asked to repeat back out loud; accuracy is recorded.

Senaptec Sensory Tests:

- Participants pressed two buttons on the screen with both hands.
- Either button randomly turns red at which point the participant knows to remove their finger from that button
- Time between button turning red and participant pulling finger off is recorded as reaction time.

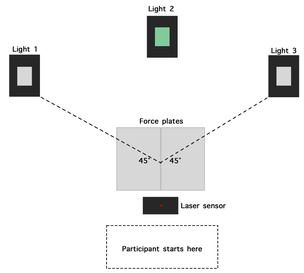

Figure 1. Data collection setup.

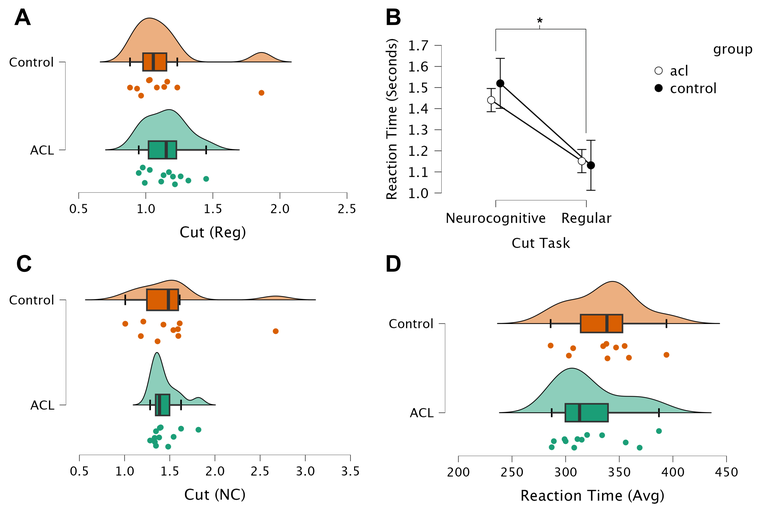

Figure 2. Raincloud Plots for Regular (Reg), Neurocognitive (NC) Cutting Tasks, Average Reaction Time assessed in Senaptec. A,B, and C are all measured in seconds and D is measured in milliseconds. D is reaction time average from Senaptec Sensory test.

RESULTS

Physical Task Reaction Time

Mixed-effect ANOVAs were used to assess the differences between the two groups (ACLR and control) across two conditions (regular and NC conditions) for the physical tasks. Post-hoc comparisons with Holm-corrected p-values were further used to explore significant effects (Table 2).

The regular condition single-leg hop was the only physical task to demonstrate a statistically significant between-group main effect (Table 1, MD: -0.204, p=.045). All physical tasks demonstrated statistically significant within-group main effects (Table 2, p<.001). There were no significant interaction effects.

Sensory Board Reaction Time

Independent T-tests were used to assess mean differences between groups (ACLR and control) for sensory board reaction times. Senaptec sensory reaction times were not found to be different between groups (Figure 2D).

Task	ACLR (Mean ± SD)	Control (Mean ± SD)	Mean Difference
Cut (NC)	1.440 ± 0.154	1.520 ± 0.454	-0.080
Cut (Reg)	1.151 ± 0.151	1.131 ± 0.279	0.002
Drop Vertical Jump (NC)	1.508 ± 0.112	1.533 ± 0.321	-0.025
Drop Vertical Jump (Reg)	1.239 ± 0.168	1.242 ± 0.093	-0.003
Lateral Vertical Hop (NC)	1.563 ± 0.315	1.677 ± 0.315	-0.114
Lateral Vertical Hop (Reg)	1.124 ± 0.185	1.221 ± 0.241	-0.097
Single Hop (NC)	1.531 ± 0.209	1.603 ± 0.283	-0.072
Single Hop (Reg)*	1.068 ± 0.184	1.272 ± 0.263	-0.204

Table 1. Descriptive statistics table for both neurocognitive (NC) and regular (Reg) trials. Standard deviation is denoted as SD. All values are measured in seconds (sec). Mean difference is calculated as ACLR – Control. *Single Hop (Reg) was found to be statistically significant.

Neurocognitive Trials	Regular Trials	t	p	Mean Difference	SE Difference
Cut (NC)	Cut (Reg)	8.506	< 0.001	0.334	0.039
Drop Vertical Jump (NC)	Drop Vertical Jump (Reg)	6.400	< 0.001	0.279	0.044
Lateral Vertical Hop (NC)	Lateral Vertical Hop (Reg)	12.735	< 0.001	0.447	0.035
Single Hop (NC)	Single Hop (Reg)	10.706	<0.001	0.403	0.038

Table 2. Post-hoc within-person comparisons. Neurocognitive (NC) and regular (Reg) conditions. Standard error is denoted as SE.

DISCUSSION

ACLR patients under the age of 25 returning to sport have a 23% ipsilateral ACL reinjury rate making recurrence a major hurdle for athletes.[3] RTS testing is generally focused on physical measures, often not including the cognitive load that athletes commonly face while engaging in sports.[1] This study aimed to analyze the impact of cognitive load on reaction time for individuals who’ve undergone ACLR. While this study found **no difference between groups**, we did find that reaction time slowed when individuals were under neurocognitive loading during tasks. Slower reaction times during physical tasks have been shown as a potential injury risk factor.[5] Looking forward, further research with larger sample sizes and less variability in timing post clearance for return to sport post-ACLR is warranted to better inform differences in reaction time compared to healthy controls.

Reaction Time:

- Delayed reaction time is an indicator of elevated risk of lower extremity injuries.[4]
- Reaction time is modifiable which could reduce the risk of injury for athletes.[5]

Key Findings:

- Reaction time during physical and sensory board tasks was not different between individuals post-ACLR and matched controls.
- Neurocognitive dual-tasking slowed reaction time in both groups during physical tasks.

REFERENCES

1. Burgi CR, et al. Br J Sports Med. 2019.
2. Hughes G, et al. Sports Biomech. 2023.
3. Wiggins AJ, et al. *American J Sports Med*. 2016.
4. Wilkerson GB, et al. *Human Kinetics J*. 2012.
5. Wilkerson GB, et al. *Human Kinetics J* 2017.

Contact Information:
sahajs@unc.edu

Our Mission is to Explore, Educate & Engage in MUSCULOSKELETAL INJURY PREVENTION