Measuring and Analyzing Reaction Times of Student Athletes in Different Sports Programs

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Abstract

This study examines the reaction times of student athletes from various sports (Track and Field and E-Sports) at Lawrence Technological University using Vex IQ Robot Touch LED sensors. The purpose of this study is to develop a robotic tool to measure reaction time and use that robot to determine whether athletes in different sports programs exhibit significant differences in reaction speed. Participants must complete 3 trials in which a red light randomly appears on one of the five Touch LED sensors, and their reaction times are recorded in milliseconds. After their trials, athletes are able to review their average reaction time for each trial, as well as their overall average reaction time, best reaction time, and standard deviation over the three trials. The results indicate that average reaction performance remains relatively consistent across gender, age, and type of sport, suggesting that individual variability may play a more significant role than demographic factors. Although males demonstrated slightly faster peak reaction times, the overall average performance did not significantly differ between groups.

Introduction

Reaction time is a critical performance metric in sports, especially in activities that require quick reflexes and decision-making. This study focuses on comparing reaction times of student athletes across various athletic teams. While many athletic programs emphasize speed, agility, and strength, fewer tend to investigate the cognitive speed and responsiveness of their athletes. The niche lies in analyzing and quantifying these abilities using a programmable VexRobot tool with LED Sensors, which evaluates visual reaction speed through a consistent, accessible method. With further development, this interactive STEM tool could be expanded to assess more complex cognitive responses- such as auditory cues or multi-sensory input (i.e. touch or vibration) - opening possibilities for integration into athletic programs for enhanced performance analysis, cognitive training, or even recruitment evaluation of athletes.

Challenge

The main challenge of determining whether athletes from different sports programs exhibit significant differences in reaction speed, is the lack of accessible and repeatable tools available for measuring reaction times across athletic settings. In athletic training and performance evaluation, among the many physical metrics that are widely emphasized, cognitive performance is equally important, especially in sports that require rapid decision-making, hand-eye coordination, and situational awareness. However, despite it being critical to assess reaction time, it is rarely assessed with consistent, standardized tools; traditional reaction time tests are often basic, inconsistent, or hard to access - limiting their use in real training environments. Most tests focus solely on measuring visual responses and don't reflect the full range of cues athletes experience during competition, which is why we chose to address this by first developing an affordable, consistent, and programmable tool to measure visual reaction time accurately, then discuss the potential to expand the tool to test more complex, multisensory responses in athletes.

Solution

To address the inconsistency and inaccessibility of tools for measuring reaction time in athletic programs, we developed a custom VexRobot system with ROBOTC programming, designed for repeatable, objective testing. The robot features five Touch LED sensors, equally spaced across the front of the platform, with a with a central screen that displays and stores the following metrics: reaction time (in milliseconds) for each trial, average reaction time per trial, best reaction time per trial, and standard deviation of all reaction times. Before each trial, the system plays a number of chimes depicting which trial is about to begin (i.e. one chime for Trial One), while displaying this information on the screen as well. During each trial, a red light will randomly activate one one of the five LED Touch sensors, prompting the athlete to respond by pressing the correct sensor as quickly as possible - this occurred a total of five times for each trial. Additionally, in between the five trials per First, Second, and Third trial, we had the athletes return their hands to the table after pressing each red light that appeared, to keep measurements consistent and fair. This setup allows for standardized, repeatable testing that is engaging, portable, and suitable for a variety of athletic environments. While this study did focus mainly on visual reaction cues, the system is fully programmable and has the potential to incorporate auditory or tactile stimuli into it, to enable a broader, multisensory assessment of cognitive response in athletic performance.

VexIQ Robot with LED Touch Sensors

Figure 1: VexRobot central screen depicting directions

Figure 2: VexRobot central screen depicting a main Trial starting

Figure 3: VexRobot central screen depicting a Trial time (in ms)

Figure 4: VexRobot central screen depicting final results (in ms)

Figure 5: VexRobot with Touch LED Sensors equipped evenly across top of central screen

Best and Average Reaction Time

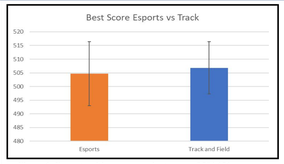

Figure 6: E-sports with an average best score of 504.656 ms versus Track and Field average best score of 506.852 ms.

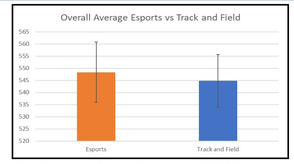

Figure 7: E-sports with an overall average score of 548.348 ms versus Track and Field overall average score of 544.804 ms.

Although there were no statistically significant differences in best or overall average reaction times between the E-Sports team and Track and Field, this similarity suggests that visual cue-based reaction time tests may not be sensitive enough to reflect the distinct cognitive demands shaped by different types of athletic training. While both groups likely develop strong visual-motor response systems through their respective sports, the uniformity in scores implies that simple visual reaction time tasks capture only a baseline level of cognitive processing. As such, these tests may overlook training-specific adaptations—such as rapid decision-making in E-Sports or explosive response to auditory cues in Track and Field—highlighting the need for more targeted and ecologically valid measures to distinguish cognitive performance across athletic domains.

Age Group Comparison

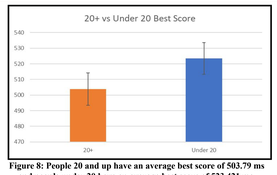

Figure 8: People 20 and up have an average best score of 503.79 ms and people under 20 have an average best score of 523.421 ms.

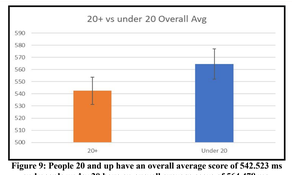

Figure 9: People 20 and up have an overall average score of 542.523 ms and people under 20 have an overall average score of 564.478 ms.

Although there were no statistically significant differences in best or overall average reaction times between age groups, the 20 years and older group demonstrated slightly faster reaction speeds overall. This subtle trend may suggest that while age alone is not a leading cause of difference in basic visual reaction time, individuals in older age groups might benefit from more developed cognitive processing or greater task familiarity. However, due to the lack of significance, this could also suggest that it is not a sensitive enough measure to detect more cognitive changes in this age range due to the close proximity of similar reaction times.

Gender Comparison

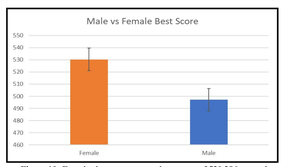

Figure 10: Females have an average best score of 530.286 ms and Males have an average best score of 497.1675 ms.

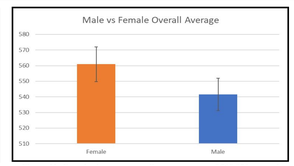

Figure 11: Females have an overall average score of 560.921 ms and Males have an average best score of 541.555 ms.

A statistically significant difference was found between males and females in best reaction times ($p = 0.05$), with males demonstrating slightly faster peak reaction speeds. However, despite the difference in best scores, no significant difference was observed in overall average reaction times between the two groups. These findings suggest that while there may be small differences in peak performance, general cognitive response speed is largely comparable. It is also important to note that this testing was conducted exclusively with cisgender student athletes, which means that the results may not account for the broader spectrum of gender identity and its potential influences on cognitive or motor performance, if any. Additionally, because participants were drawn from different sports teams, variations in training type, physical demands, and sport-specific cognitive development may have influenced individual performance and should be considered when interpreting the results.

Implications of Results

The findings suggest that peak reaction ability may be influenced by gender, with males showing slightly faster reaction times in this study, though the difference was minimal. However, the absence of a significant difference in average reaction times between the two gender groups—comprised exclusively of cisgender student athletes—indicates that gender may not play a major role in consistent reaction performance. This underscores the importance of individual variability, as factors such as training, experience, and other personal characteristics may contribute more to reaction time than demographic groupings alone.

Similarly, the lack of significant differences in reaction times between E-Sports and Track and Field athletes suggests that the type of sport may not strongly impact reaction speed, or that the specific demands of these sports do not directly translate to differences in visual reaction performance. Additionally, the absence of significant age-related differences between younger and older participants suggests that peak reaction times may remain relatively stable across this age range.

Several limitations of the study should be considered. Outliers—such as late starts or confusing trials—may have skewed results, particularly in the interpretation of peak reaction times. Furthermore, the study's exclusive use of a visual reaction test limits its ability to assess other types of reactions, such as auditory or multi-sensory responses, which may yield different insights. Future research should broaden the scope of reaction time assessments to include a wider range of stimuli and consider additional factors like sport-specific training, mental state, and long-term cognitive development. Longitudinal studies, in particular, could offer valuable insight into how reaction times change over time and how various influences interact to shape performance.

Discussion & Future Directions

Building on the findings of this study and the potential of tools like the programmable VexRobot, future research should aim to explore the physiological mechanisms underlying gender differences in peak reaction times and consider other variables, such as training intensity, sport-specific cognitive demands, and neurological processing speed. Expanding the tool to measure multisensory responses - such as auditory or tactile stimuli - could offer a more comprehensive view of how athletes respond to real situations. Furthermore, increasing the sample size to encompass a wider range of sports and age groups, alongside longitudinal data collection, could provide valuable insights into how reaction time develops over an athlete's lifespan, and how psychological or environmental factors may either enhance or hinder performance. These directions align with the ongoing need for accessible, consistent, and sport-relevant cognitive assessment tools in athletic training programs.

Acknowledgements

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