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The Test-Retest Reliability and Minimal Detectable Change of the FitLight Trainer™

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ABSTRACT

Reaction time is commonly used as an indicator of cognitive function post-concussion and is an important measurement in return-to-play protocols. Current post-concussion assessments lack evidence regarding their reliability and do not simulate real-world functional movement patterns and choice reactions that occur in sport performance. This study sought to establish the test-retest reliability of the FitLight Trainer™ a novel piece of equipment that can evaluate reaction time in a non-concussed, healthy population. Repeated measures. Twenty-six (14 males, 12 females) healthy individuals (age 20.5 ± 1.8 years, height 171.4 ± 7.5 cm, weight 71 ± 12.7 kg, hand dominance right-23, left-3) from Bowling Green State University participated. Choice reaction time was assessed at two separate time intervals (7 days apart). Subjects completed three trials each session. Subjects were asked to reach out and tap a series of 8 lights mounted to the wall as quickly as possible. The dependent variable was choice reaction time, and the independent variable was session (session 1, session 2). Good test-retest reliability was demonstrated for choice reaction time using the FitLight Trainer™ across the two testing sessions (ICC2,1 = .89, p= 0.000). Minimal detectable change (MDC) values were recorded for session 1 (79.9 ms) and session 2 (78.5 ms). The FitLight Trainer™ provides reliable measures of reaction time in a healthy population. Considering its ease of use, versatility and portability during testing procedures, the FitLight Trainer™ could be considered a practical standard for evaluating choice reaction times. Determining the test-retest reliability and minimal detectable change of the FitLight Trainer™ as a valid measure for testing reaction time in a healthy population was an important first step. Future studies should evaluate the test-retest reliability of the FitLight Trainer™ in pathological populations.

Keywords: **Reaction time, FitLight Trainer™, Concussion Assessment, Test-retest reliability**

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THE TEST-RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE OF THE FITLIGHT TRAINER™

Concussive injuries, while commonly associated with sport, also occur in both the clinical and general populations. Increasing numbers of people partaking in recreational activity has led to more individuals sustaining traumatic brain injuries (TBI), particularly those that are "mild" in nature, known as a concussion (McInnes et al., 2017). Langlois and colleagues (2006) state that in the United States alone, there is an average of 1.4 million concussive injuries that occur each year. This estimation, however, does not include any mild traumatic brain injuries (MTBIs) that are not reported or diagnosed. Knowing that the incidence of concussive injury could be much higher than what is estimated is an alarming fear for not only clinicians, but coaches and athletes as well.

Post-concussion recovery is measured using a variety of assessment tools. These assessment tools are designed to evaluate a variety of things, such as balance, cognition, memory, vestibular function, and reaction time. Some common assessment tools include the Sports Concussion Assessment Tool (SCAT-5), the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) (Wolf & Fast 2017; Mullally, 2017), CogState Sport, Automated Neuropsychological Assessment (ANAM) (Eckner et al., 2011) and the Balance Error Scoring System (BESS). Currently, the SCAT-5, which is a tool that targets the immediate clinical signs and symptoms of sport related concussions, is considered the standard sideline assessment device when diagnosing a concussion (Lee et al., 2017). This tool, however, has little published evidence regarding the effectiveness for determining cognitive changes long-term. For example, Hänninen and colleagues (2021) reported a low reliability coefficient (r = .58). for the retest sessions of the cognitive assessment for the SCAT-5. Additionally, Echemendia and colleagues found that the effectiveness of the SCAT-5 and its corresponding components decreased

significantly 3-5 days post-injury, indicating that the tool is better suited for helping diagnose concussions rather than aiding in the return-to-play decisions (Echemendia et al., 2017). The ImPACT test, another common concussion assessment device, is a computer-based program that allows clinicians to assess cognitive function along with the presence of concussion symptoms (Covassin et al., 2009). It is commonly used to gather baseline data about an athlete's cognitive state before an injury has occurred, to then determine where deficits occur in cognitive performance following a sport related concussion. This tool is one of the most widely used computer programs in sport settings; however, there is still limited data as to whether sports medicine professionals use the baseline data at high school and college levels to determine effective return-to-play protocols (Covassin et al., 2009).

CogState Sport and ANAM are computerized neurocognitive tests (CNTs), that are also commonly used to assess athletes with sport-related concussions by evaluating reaction time, mathematical processing ability, matching, Go/No-Go, and memory (Nelson et al., 2016). The BESS is used to evaluate baseline measures of balance before a concussion has occurred and post-concussion by using a series of different stances including single-leg, double-leg and tandem on both a firm and foam surface (Finnoff et al., 2009). These tools are the primary concussion assessment devices used in the sports medicine fields, yet there is still little published evidence regarding their validity and reliability. Determining which assessment device to use is strictly up to the healthcare provider or clinician. As mentioned above, there are several options to choose from but currently there is no "gold" standard for post-concussion symptom evaluation and management that encompasses the multiple facets required during athletic events such as reaction time, agility (Reigal et al., 2019; Perroni et al., 2018), balance (Verschueren et al.,

2019), decision making (Walton et al., 2018) and information processing speed (Eckner et al., 2011).

In concussion testing, reaction time (RT) is one of the most widely used assessments because it is a good indicator of cognitive changes post-concussion (Eckner et al., 2011). Impaired RT is a symptom commonly seen following a sport-related concussion (Eckner et al., 2011). Along with subjective symptom reporting and routine physical examinations, cognitive testing is a viable part of ensuring that an athlete is fully recovered. Covassin and colleagues state that implementing CNTs to evaluate baseline preinjury and serial post injury has resulted in increased detection of post-concussion cognitive deficits when comparing individual data to normative data (Covassin et al., 2009). Increased awareness of acute cognitive changes following a concussion could help decrease the risk of additional injury an athlete faces when returning to their sport. Therefore, evaluation of an athlete's post-concussion recovery is crucial in determining if they are ready to return to play both physically and cognitively (Cripps et al., 2016). If an athlete were to return to play without following the appropriate protocol, the risk for secondary injury increases tremendously, which could lead to more permanent effects later in life (Torres et al., 2013).

With increasing participation in sporting activities, concussion prevalence is increasing faster than the current research being conducted on the topic. Even with the vast amount of knowledge that is available regarding the short and long-term effects of concussions, there is still a gap in what is known about them. One point that is understood however, is that impaired cognitive function is one of the most serious consequences that results from concussions, which can affect attention, memory, and learning (FitLight Corp, Ontario, Canada). The FitLight Trainer™ was created to help combat those effects by challenging a person's cognitive abilities

through interactive training to enhance visual tracking, motor coordination, processing speed and memory (FitLight Corp, Ontario, Canada).

The FitLight Trainer™ appears to be more accessible in testing reaction time in many populations, particularly those who have sustained a concussion, compared to other tools that are currently being used. The FitLight Trainer™ is a new piece of equipment, which can be used to simulate various movement patterns and choice reactions that are necessary in fast paced sports such as soccer, basketball, and hockey (Verschueren et al., 2019). The Fit Light Trainer® is a wireless reaction system comprised of eight LED lights controlled by a tablet computer that can be used to analyze many factors of athletic performance including balance (Verschueren et al., 2019), reaction time (Reigal et al., 2019; Perroni et al., 2018) and agility (Rauter et al., 2018; Čoh et al., 2018). The LED lights can be programmed to be deactivated either by direct contact or proximity, which allows the device to be used in a variety of settings (Rauter et al., 2018).

The FitLight Trainer® incorporates many aspects of existing concussion assessment equipment but provides greater potential to customize training and rehabilitation programs specific to individuals. The FitLight Trainer™ system helps to improve reaction time, response time, identification of stimuli, focus, memory, and motor/sensory skills (FitLight Corp, Ontario, Canada), which are important factors of injury prevention and successful sport performance in continuously changing environments (Verschueren et al., 2019). This reactive training system, while still relatively new, has been used to enhance training and performance results by teams and strength/conditioning personnel within the NFL, NBA, and MLS as well as in the healthcare and military fields (FitLight Corp, Ontario, Canada). The FitLight Trainer™ allows clinicians and athletic trainers to set baselines, which is especially important when referencing where an athlete falls on the severity of symptoms scale in post-concussion management. Due to its ease of use,

the FitLight Trainer™ can be set up in any space making it a potentially valuable tool to have not only for laboratory testing but for field testing as well. While clinicians should do what is in the best interest of the patient, the FitLight Trainer™ could be another useful device, especially when referencing the current concussion battery.

Currently, there is no published evidence relating to the test-retest reliability of the FitLight Trainer™ in a healthy population. Establishing the test-retest reliability of the FitLight Trainer™ as a valid measure for testing reaction time in a healthy population is an important first step. Once reliability has been established in a healthy population, clinicians and researchers can then use the FitLight Trainer™ to assess reliability in pathological populations, including those recovering from a sport-related concussion. Thus, the aim of this study was to establish the test-retest reliability of the FitLight Trainer™ in a healthy, non-concussed population.

LITERATURE REVIEW

The following literature review will examine various aspects of concussion management. Specifically, concussion prevalence in the United States along with a brief mentioning of current protocols that are used to assess and diagnose an athlete's post-concussion recovery will be examined to help determine the test-retest reliability of the FitLight Trainer™. In addition, the importance of reaction time and practical recommendations to consider when determining if an athlete is ready to return to play will be discussed.

Concussion Prevalence

Concussive injuries have become one of the most difficult injuries for clinicians to evaluate and treat. While there are signs and symptoms most associated with concussions, every individual's encounter is different regarding recovery, symptoms experienced, and lasting effects. In the United States, an average of 1.4 million concussive injuries occur each year,

including 1.1 million emergency department visits, 235,000 hospitalizations, and 50,000 deaths (Langlois et al., 2006). These numbers may be misleading though, as many mild traumatic brain injuries go undetected or misdiagnosed, especially in athletic populations (Langlois et al., 2006). In a survey conducted by the University of Pennsylvania, it was found that of the 262 athletes who responded, 43% stated that they knowingly hid their symptoms to stay in the game (Torres et al., 2013). These are concerning numbers, indicating that the prevalence of concussion could be much higher than what is currently estimated. Contrary to popular belief, a concussion does not refer solely to a head injury but rather to the mildest form of a traumatic brain injury (Mullally, 2017). A TBI can occur when the head violently hits an object or when an object pierces the skull and enters brain tissue (NIH, 2019). A MTBI is the most common type of traumatic brain injury (McInnes et al., 2017) and is caused from traumatically induced physiological disruption of brain function that often includes the head being struck, the head striking an object, and the brain undergoing an acceleration/deceleration movement such as whiplash (Kay et al., 1993).

Concussions can occur in any setting but are frequently associated with sports (Langlois et al., 2006), especially those where contact can occur, such as football, hockey, and soccer (Mullally, 2017). Sport concussions seem to be more prevalent in individuals between the ages of 15-24 and represent the second leading cause of concussions, behind motor vehicle accidents (MacDonald et al., 2015). It is estimated that approximately 44 million children and 170 million adults participate in some form of sports-related activity regularly (Mullally, 2017). With growing numbers of people participating in sports and athletic events, the number of individuals sustaining traumatic brain injuries is steadily on the rise (Mullally, 2017). This creates a greater

need in the healthcare field for professionals to be able to diagnose, implement effective treatment and provide recommendations for preventing secondary injury (Mullally, 2017).

To improve the diagnosis and management of concussions, a comprehensive examination, including symptom inventories, balance examination, and neuropsychological assessments have been suggested. These measures are critical in determining if an athlete is ready to return to play (Cripps et al., 2016) both physically and cognitively. Without these assessments, the danger of participating (Cripps et al., 2016) is greatly increased if a second concussion were to occur (Torres et al., 2013). Unfortunately, though, the return-to-play protocol is highly dependent on the athlete reporting the presence and severity of their symptoms (Cripps et al., 2016), which does not always happen.

Current Concussion Assessment Tools

Current concussion assessments include tests such as the SCAT-5, the ImPACT (Wolf & Fast, 2017; Mullally, 2017), CogState Sport and the ANAM (Eckner et al., 2011). The problem with these measures is two-fold though. First, there is a lack of evidence regarding the reliability of many of these tools. Second, many of these tools do not simulate real-world functional movement patterns and choice reaction time (Perroni et al., 2018). In a study conducted by Covassin and colleagues (2009), it was found that 94.7% of athletic trainers administered baseline neurocognitive testing to their athletes but only 51.9% examined these assessment tools for validity. Considering that these are the primary assessment tools used in post-concussion assessment, it is alarming that only half of the athletic trainers administering these tests evaluated their validity.

Nelson and colleagues compared the reliability and validity for the three most common CNTs (ANAM, CogState Sport and ImPACT) used in concussion assessment and found that the

test-retest reliability was similar among the three devices and below optimal values for use in a clinical setting (Nelson et al., 2016). Across multiple previously conducted studies, ANAM showed only 47% of reported reliability coefficients met the minimum standards of .60 or higher for use in a clinical setting (Nelson et al., 2017). CogState Sport has shown mixed results with some studies indicating a low reliability coefficient (ICC= 0.45-0.67) and other studies indicating a strong reliability coefficient (ICC = 0.76, r = 0.79, & ICC = .83-.93) for all four subsects (Collie et al., 2003; Eckner et al., 2011; Louey et al., 2014; MacDonald and Duerson, 2015; Nelson et al., 2017).Notably the most widely used CNT, ImPACT testing, has also revealed variable reliability coefficients in some samples compared to others across high school, college, and professional sports as well as in non-athlete populations (Nelson et al., 2017). Neurocognitive assessment tools (NCAT) such as ImPACT, CogState, and ANAM have gained popularity in both athletic and military settings within the last 10-15 years and have been identified as critical components in post-concussion management (Arrieux et al., 2017). However, while the use of these devices is imperative for the management of return to play protocols, the validity and clinical utility of NCATs have not been consistently established (Arrieux et al., 2017).

Importance of Reaction Time

Reaction time is an important component in the sports medicine field. Many sporting activities require athletes to complete movement tasks under severe temporal pressure (Causer et al., 2013) while constantly assessing and processing large numbers of sensory stimuli (Perroni et al., 2018). An athlete's ability to respond to these changing stimuli by adapting their responses are of great importance to sport performance and injury prevention (Verschueren et al., 2019). Head injuries acquired during sports, particularly those with high amounts of contact, can result

in long-term physical, cognitive, behavioral, and emotional consequences if not properly treated (Langlois et al., 2006). Physical symptoms attained from concussive injuries such as headaches, fatigue and depression typically resolve in most individuals within three months (McInnes et al., 2017); however, cognitive impairments such as reaction time often last much longer and may persist beyond the resolution of self-reported symptoms (Eckner et al., 2011).

Reaction time (RT) is a frequently and widely accepted measure used to assess processing speed and response efficiency in information processing tasks (Perroni et al., 2018) as well as in cognitive and perceptual processes (Gutiérrez-Davilla et al, 2017). Causer and colleagues define RT as the total time for all neural processes to occur, beginning with information entering the photoreceptors and ending with the motor response (Causer et al., 2013). In simpler terms, RT is the speed at which a person can move in response to a specific stimulus (Liu et al., 2018). Reaction time can be divided into two main categories: simple RT and choice RT. Simple RT is defined as the interval time between when a single stimulus appears, when the person detects said stimulus and the given response that is associated (Reigal et al., 2019). Choice RT refers to the identification and selection (Reigal et al., 2019) of two stimuli that require two different responses (Gutiérrez-Davila et al., 2017).

Reaction time is an important component of successful sport performance as it allows athletes to respond quickly to changing and often unstable environments. Reaction time often encompasses whole-body based movements, which must be synchronous for athletes to compete successfully and prevent injury (Lempke et al., 2020). It is present in most sports ranging from catching a ball in football, baseball, and softball, to deciding who to pass to in soccer, hockey, and basketball. In sporting events, athletes are often faced with the decision to choose from multiple stimuli, which could lead to various outcomes depending on the choice that is selected.

Having the ability to correctly identify and act upon presented stimuli could be the difference in success and failure as well as the difference in getting injured and not.

It is well known that concussive injuries cause deficits in reaction time as this has been demonstrated repeatedly (Eckner et al., March 2011; Eckner et al., 2011; Lempke et al., 2020; MacDonald et al., 2015). Reaction time, therefore, is considered a critical post-concussion outcome measure (Lempke, 2020) as it allows clinicians to evaluate cognitive changes that occur because of traumatic brain injuries. Baseline reaction time measures are important for evaluating several factors including performance and progress in rehabilitation. Implementing reaction time into initial baseline testing is imperative for understanding the results of an athlete's performance following a concussion. Unfortunately, normative standards do not always represent every individual's recovery following a concussion, which is why baseline testing is important because it allows athletes to be compared against their own results. If an athlete were to sustain a concussion without having baseline data to compare to, it would be difficult to determine whether the athlete's post-concussion performance was due to the concussion or because of individual variability (Covassin et al., 2006; Covassin et al., 2009).

Deficits in reaction time often coincide with other post concussive symptoms, however it has also been shown to persist beyond the resolution of other commonly seen physical symptoms (Eckner et al., March 2011; Eckner et al., 2011). Lempke and colleagues conducted a systematic review on reaction time deficits following a concussion and found that decreases in reaction time can be seen within the first three days after a concussion and can persist until around 59 days post-injury (Lempke et al., 2020). The continuation of impaired reaction time following a sport-related concussion makes creating recovery protocols difficult for clinicians, especially when no baseline values are available for comparison.

Additionally, many studies have indicated that athletes who have sustained multiple concussions are more likely to experience prolonged deficits in reaction time measures compared to athletes who have only sustained one concussion (Collins et al., 1999; Covassin et al., 2008; Covassin et al., 2013; Guskiewicz et al., 2000; Guskiewicz et al., 2003; Iverson et al., 2012; Mannix et al., 2014). For example, Broglio and colleagues found that 38% of athletes demonstrated cognitive impairments even while being asymptomatic (Broglio et al., 2007). Knowing that cognitive impairments are still present even when athletes are not experiencing physical symptoms makes the return to play protocol that much more important to help prevent further injuries and concussions (Covassin et al., 2013; Eckner et al., March 2011).

This is important for clinicians to be aware of because even though athletes appear to be back to "normal," cognitive functioning continues to remain impaired. Numerous studies have indicated that deficits in reaction time could predispose an athlete to further injury, including additional head injuries (Eckner et al., March 2011; Lempke et al., 2020; MacDonald et al., 2015; Thomas et al., 2011) making pre-mature return to play an important component for physicians to consider in concussion management. When determining if an athlete is ready to return-to-play, it is important to make sure that their post-concussion performance returns to their baseline results, regardless of the time it takes to get to that point (Covassin et al., 2006).

Practical Recommendations

Clinical recovery from concussion is often based on subjective reporting of symptoms along with observations of balance control (Mitchell et al., 2019). However, neurocognitive assessment following a concussion is an integral piece for the healthcare practitioner in understanding where the athlete is at on the recovery timeline and if they are ready to return to play. Following a traumatic brain injury, patients should be free of symptoms before being

cleared to begin the return-to-play protocol (Mullally, 2017) but the recovery protocol should encompass a multifaceted approach that includes all aspects pertaining to athletics. Athletics not only involves a combination of several physical aspects such as reaction time and agility but also cognitive aspects including attention and decision making (Walton et al., 2018). It is important, therefore, when determining if an athlete has fully recovered to include subjective symptom resolution, normalization of a physical examination and cognitive assessments (Eckner et al., 2011).

METHODS

Research Design

A repeated-measures design was used for this study. Choice reaction time was assessed in a healthy, non-concussed sample at two separate time intervals (7 days apart) in a university research laboratory setting. This time point was chosen to represent the typical amount of time in concussion return-to-play protocols. The dependent variable for this study was choice reaction time and the independent variable was session (session 1, session 2).

Participants

Participants that met the inclusion criteria (ability to speak and understand the English language, between the ages of 18-24, no history of a concussion within the previous six months) were eligible to participate. Twenty-six (14 males, 12 females) healthy individuals (age 20.5 ± 1.8 years, height 171.4 ± 7.5 cm, weight 71 ± 12.7 kg, hand dominance right-23, left-3) from Bowling Green State University participated in this study. Exclusion criteria included a diagnosed concussion within the previous six months or the presence of post-concussion symptoms if longer than 6 months, any neurological or orthopedic condition that may affect reaction time, any upper-limb injury still causing current pain or disability, and any conditions that can affect information processing such as visual processing disorder. Some examples of

conditions that could affect reaction time include Arthritis, Multiple Sclerosis (MS), Parkinson's disease, and Traumatic Brain Injury (TBI). Subjects with any of these conditions were excluded from the study. Additionally, one participant who did not complete the second testing session was excluded from the study.

Instruments

The instruments that were used included the Ishihara pseudoisochromatic color blindness test (Birch, 1997) and the FitLight Trainer™ (FitLight Corp, Ontario, Canada). The Ishihara test is designed to provide a quick and accurate assessment of color vision deficiency that is present at or prior to birth (Ishihara, 1917). The Ishihara test contains a total of 38 plates (Birch, 1997). The first 25 plates contain various patterns each engraved with a number, which the subject must identify, while the remaining 13 plates contain only patterns and are rarely used because they are intended for non-verbal subjects (Figure 1), (Birch, 1997). Many people with color blindness demonstrate some form of red-green deficiency (Ishihara, 1917) making this test an important assessment tool to ensure that the participants can see the stimulus that is being presented.

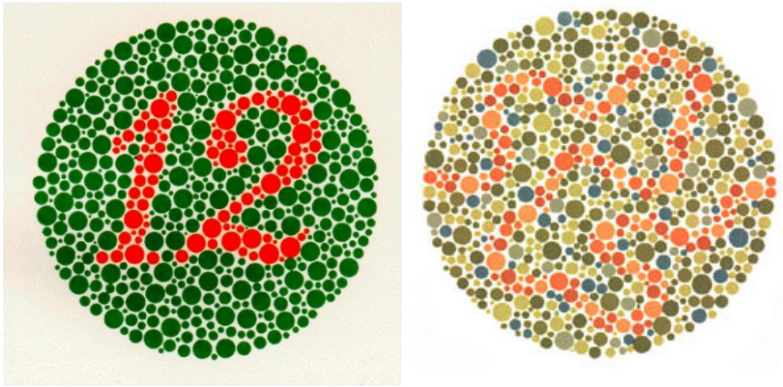

Figure 1. Ishihara Plate Examples. The plate on the left is used for number recognition and the plate on the right is used for pattern

This test is the most widely used screening tool for red-green color deficiency and clinical trials show that it is the most effective (Birch, 1997). Results obtained from a study conducted by Birch (1997) showed a combined sensitivity of the Ishihara plates to be 95.5% on

eight errors, 97.5% on six errors and 99.0% on three errors made. Test specificity was determined to be 94.1% for three errors, 95.4% for six errors and 100% for eight errors (Birch and McKeever, 1993). Traditionally, the Ishihara plates come in a book that is set up with a specific light frequency; however, for this study, the Ishihara test was taken on a computer using the Colblindor Ishihara 38 plate online color test. Staden and colleagues determined that the Colblindor Ishihara 38 plate online color test was able to accurately detect individuals with red-green color deficiency showing sensitivities and specificities of 100% (Staden, 2018).

The FitLight Trainer™ is a wireless reaction system composed of eight LED lights controlled by an Android tablet computer. The system can be used to measure many factors of athletic performance including agility, reaction time, speed, and coordination (Rauter et al., 2018). The lights have an internal sensor which reacts to proximity or touch to deactivate the light (Perroni et al., 2018). Each light can be programmed independently or as a group with varying stimulus patterns and durations (FitLight Corp, Ontario, Canada). Along with the ability to program different sequences for each light, the FitLights® can be mounted on any surface including walls, poles, the floor, and other training equipment (Perroni et al., 2018).

Procedures

This study was approved by the Bowling Green State University Institutional Review Board. Participants that met the inclusion criteria were asked to report on two different occasions to the laboratory where testing took place. All subjects signed an informed consent document upon arrival. Participants were then asked standard demographic questions including age, height, weight, sex, and hand dominance (what hand they would write with). Subjects were screened for pre-existing balance, vestibular, and/ or neurologic conditions by asking each subject to disclose any previously diagnosed medical conditions. Participants were then administered the Colblindor

online test to determine if color blindness was present. Subjects were asked to identify the number that was written on a series of 25 plates along with the number of lines presented on the remaining 13 plates. No participants exhibited a red-green color deficiency, therefore, the colors of the FitLights® remained the same for all subjects.

Following the color blindness test, participants were given the opportunity to complete a practice trial as many times as necessary to get familiar with the equipment that was used during testing. After the practice trial, there was a period for the participant to ask any questions they had about the testing protocol, if necessary. For this study, eight LED FitLights® were mounted to a wall positioned in two rows of four directly in front of the participant. The first row of FitLights® was set at a standard height of 60 inches measured from the bottom of the wall. The second row of FitLights® was set at a standard height of 48 inches measured from the bottom of the wall. Each light was separated by 12 inches both horizontally and vertically measured from the center of each FitLight®. The placement of the FitLights® remained the same for all participants throughout each trial. The set-up of the FitLights® and the participants is shown below in Figure 2.

A tablet computer recorded reaction time data as the participants were completing the task. Prior to testing, the lights were pre-programmed with the specific trial sequences and appropriate colors. Intensity of the light stimulus was set to low and distance sensitivity was turned off because the lights were deactivated by impact rather than proximity. The participants were positioned standing 30 cm from the wall, with their body facing towards the eight FitLights® attached to the wall. Participants were instructed to stand shoulder width apart with hands at hips on the marked line on the floor. When the participants were ready to begin, the testing procedures commenced.

Subjects were instructed to reach out and tap the green light as quickly as possible using only their dominant hand and ignore any other color that appeared. The green light was used as the correct light for the participants to touch, and the red light was used as the incorrect light, which participants were instructed to ignore. Each FitLight™ illuminated in an order predetermined by the programmed sequence function on the Android tablet. A random order was implemented across the three trials to help combat the practice effect but remained consistent for each participant across both sessions. Participants completed 20 attempts per trial, returning to the starting mark between each stimulus every time. A total of three trials were completed per session. A two-minute break was given between each trial to allow subjects to rest. Each trial was evaluating the subject's choice reaction time by asking them to tap the correct light and ignore the incorrect light. Each light was set with a specific deactivation time according to the stimulus duration for each trial listed below. Throughout the three trials, participants completed the same reaction test of choosing between the correct and incorrect light, however, each trial was faster than the previous one. Each trial was characterized by the stimulus duration (length that the stimulus remains active/on) and frequency variation (the time between a visual stimulus and the following stimulus) as indicated below:

- Trial 1= 2 seconds of stimulus duration and 1.5 second interval until next stimulus
- Trial 2= 1.5 seconds of stimulus duration and 1.5 second interval until next stimulus
- Trial 3= 1 second of stimulus duration and 1 second interval until next stimulus

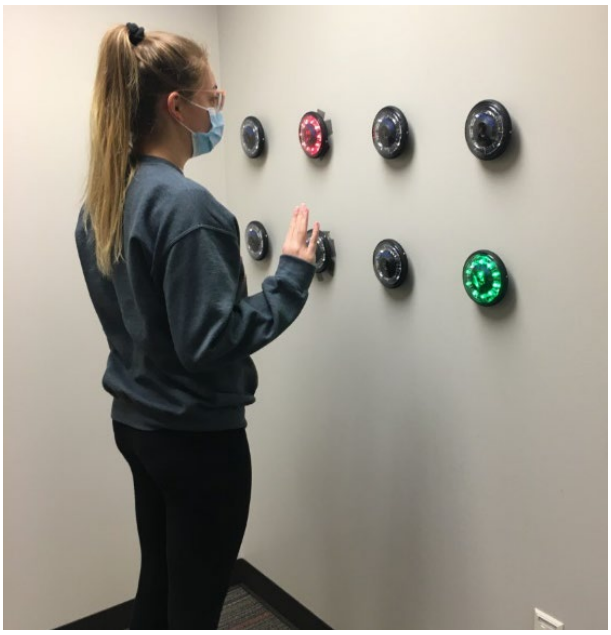

Figure 2. Set up of FitLights® and position of subjects.

At the conclusion of the three trials, participants were scheduled for the second testing session, which took place seven days following the first session. The second testing session was scheduled at the same time as the first session seven days after to represent the standard time in return to play protocol with concussions. During the second testing session, subjects were asked to complete the same three trials listed above. Total testing took approximately 20 minutes for the first session and 10 minutes for the second session. By repeating this testing procedure at one additional time point, the test-retest reliability and minimal detectable change for this equipment was established.

Statistical Analysis

Descriptive statistics, measures of central tendency, and variability were calculated to summarize the demographic characteristics of the sample (age, height, weight, sex, hand dominance). Intraclass correlation coefficients ($ICC_{2,1}$) (Koo & Li, 2016) were calculated to assess the test-retest reliability of the FitLight Trainer™ between the two testing sessions. ICC values were interpreted based on ranges of poor reliability, < 0.50; moderate reliability, 0.50-

0.75; good reliability, 0.75-0.90; and excellent reliability, 0.90-1.00 (Koo & Li, 2016). Using the reliability coefficients, the minimum detectable change (MDC) of the FitLight Trainer™ for each testing session was calculated. MDC was determined using the following formula:

MDC_{95} = 1.96 x SEM x $\sqrt{2}$ (Stratford, 2004).

The standard error of measurement (SEM) was calculated using the following formula:

SEM = s $\sqrt{1-r}$ (Stratford, 2004).

In the formula for calculating the SEM, (s) represents the standard deviation of the scores and (r) represents the reliability coefficient. An *a priori* alpha level of $P \leq 0.05$ was applied to all data to determine significant differences. All measurements were analyzed with the Statistical Package for the Social Sciences software version 26.0 (SPSS Inc., Chicago, IL.)

RESULTS

A reliability analysis was performed by calculating the $ICC_{2,1}$, the SEM, and MDC. Intraclass correlation coefficients were calculated for each session by adding the mean reaction times for each trial together and dividing by the number of trials per session. Good test-retest reliability was demonstrated between the two sessions ($ICC_{2,1}$ = 0.89, p = 0.000). Using the formula above, SEM values were calculated for session 1 (28.82 ms) and session 2 (28.32 ms). Minimal detectable change (MDC) values were also calculated using the formula above for session 1 (79.89 ms) and session 2 (78.51 ms). Descriptive statistics derived from the FitLight Trainer™ dashboard for choice reaction times are reported in Table 1. The results of the reliability analysis are shown below in Table 2.

Table 1. Descriptive Statistics for Choice Reaction Time

Descriptive Statistics	Mean Time (ms)	p-value	95% Confidence Interval
Session 1	**592.2 ± 86.9**	**.000***	**535.7, 648.7**
Session 2	**551.4 ± 85.4**	**.000***	**495.8, 606.9**

*Significant differences between session 1 and session 2, P < .05

Table 2. Test-Retest Reliability Values for FitLight Trainer™

	$ICC_{2,1}$	SEM	95% MDC
Session 1	**.89**	**28.8 ms**	**79.9 ms**
Session 2	**.89**	**28.3 ms**	**78.5 ms**

Abbreviations: ICC, intraclass correlation coefficient; SEM, Standard error of measurement; MDC, minimal detectable change

DISCUSSION

The results of this study demonstrated that the FitLight Trainer™ was a highly reliable tool for evaluating choice reaction time in a healthy population. To our knowledge, this is the first study in which validity has been established for the FitLight Trainer™ system. Across the six trials, majority of the participants performed better (quicker reaction times) in the second session compared to the first session. This could be attributed to several factors including comfort with using the equipment, and the practice effect. Although measures were taken to reduce the practice effect, mean reaction times in the second session ($\bar{X} = 551.36\ ms$) were decreased overall compared to the first session ($\bar{X} = 592.18\ ms$) (p =0.000). Trials one, two and three were kept consistent across the testing sessions for all participants, but each trial was slightly different through the stimulus frequency, stimulus variation and the order in which the lights lit up.

Determining the minimal detectable change (MDC) values for the FitLight Trainer™ in a healthy population was a secondary aim of this study. The MDC values represent the estimate of

real change in performance during testing (Cripps et al., 2016). These values are associated with the given confidence interval and allow clinicians and researchers to understand the minimum score needed to achieve significant results not due to measurement error or other factors. The MDC values found in this study can be used to help establish meaningful changes for choice reaction time.

Despite the results of the study, there were some limitations that occurred that need to be addressed. Prior to each day of testing, the FitLight Trainer™ was calibrated with the Android tablet to ensure that the FitLights® were working properly. Regular calibrations showed that the FitLight Trainer™ system was working the way it was designed to work; however, during the testing procedures some problems did occur that were related to the setup of the equipment. For this study, the FitLights® were mounted using the Velcro attachment to a wall in a research laboratory setting that had a plaster like surface. The FitLight Trainer™ system comes with eight LED lights that require daily charging in the provided charging case. To charge the lights however, the lights must be pulled off the wall every single day, which eventually caused the Velcro attachments to pull the plaster off the wall.

A problem that occurred with this setup is that due to the decreased points of contact for the Velcro attachment with the wall, the FitLights® became less stable on the wall. During some sessions, due to the impact placed on the light by the participant (i.e. hitting them harder than necessary), a few of the FitLights® were knocked off the wall. This resulted in having to stop the trial, reattach the light to the wall, and repeat the attempted trials again. This could have attributed further to the practice effect that participants might have experienced. For future studies, it is recommended to attach the lights using a backdrop on the wall or to ensure that the surface the lights are attached to can withstand the impact that participants place on them. It is

also encouraged to use the system that allows the FitLights® to be charged while remaining on the wall, as this would help maintain the surface contact with the wall. An additional limitation included a smaller sample size (N=26). Lastly, the results of this study can only be generalized to healthy adults within the age range of 18-24, as athletes, individuals from other age ranges, and pathological populations may perform differently when using the FitLight Trainer™.

CONCLUSION

In conclusion, the FitLight Trainer™ is a system that can evaluate many aspects pertaining to athletics including reaction time and decision making. Considering its ease of use, versatility and portability during testing procedures, the FitLight Trainer™ could be considered a practical standard for evaluating choice reaction times. Based on the results of this study, the FitLight Trainer™ showed good test-retest reliability ($ICC_{2,1}$ = .89) indicating that it could be a useful tool to evaluate choice reaction times compared with baseline measures. Establishing the test-retest reliability of the FitLight Trainer™ in a healthy population was an important first step. Future studies should evaluate the FitLight Trainer™ for its ability to assess reaction time in pathological populations, such as those recovering from sport-related concussions.

REFERENCES

Arrieux, J. P., Cole, W. R., & Ahrens, A. P. (2017). A review of the validity of computerized neurocognitive assessment tools in mild traumatic brain injury assessment. *Concussion, 2(1)*, 1-23.

Birch, J. (1997). Efficiency of the Ishihara test for identifying red-green colour deficiency. *Ophthalmic & Physiological Optics: The Journal of the British College of Ophthalmic Opticians (Optometrists), 17(5),* 403-408. https://www.ncbi.nlm.nih.gov/pubmed/9390366

Birch, J. and McKeever, L.M (1993). Survey of the accuracy of new pseudoisochromatic plates. *Ophthalmic & Physiological Optics: The Journal of the British College of Ophthalmic Opticians (Optometrists), 13,* 344-349.

Broglio, S.P., Macciocchi, S.N., Ferrara, M.S. (2007). Neurocognitive performance of concussed athletes when symptom free. *Journal of Athletic Training, 42(4),* 504-508.

Causer, J., McRobert, A. P., & Williams, A. M. (2013). The effect of stimulus intensity on response time and accuracy in dynamic, temporally constrained environments. *Scandinavian Journal of Medicine & Science in Sports, 23*(5), 627-634. https://10.1111/j.1600-0838.2011.01440.x

Čoh, M., Vodičar, J., Žvan, M., Šimenko, J., Stodolka, J., Rauter, S., & Mačkala, K. (2018). Are change-of-direction speed and reactive agility independent skills even when using the same movement pattern? *Journal of Strength and Conditioning Research, 32*(7), 1929-1936. https://10.1519/JSC.0000000000002553

Collie, A., Maruff, P., Makdissi, M., McCroy, P., McStephen, M., & Darby, D. 2003. CogSport: reliability and correlation with conventional cognitive tests used in postconcussion medical evaluations. *Clinical Journal of Sports Medicine, 13(1),* 28-32.

Collins, M.W., Grindel, S.H., Lovell, M.R., et al. (1999). Relationship between concussion and neuropsychological performance in college football players. *Journal of the American Medical Association, 282(10),* 964-970.

Covassin, T., Stearne, D., Elbin, R. (2008). Concussion history and postconcussion neurocognitive performance and symptoms in collegiate athletes. *Journal of Athletic Training, 43(2),* 119-124.

Covassin, T., Elbin, R. J., Stiller-Ostrowski, J. L., & Kontos, A.P. (2009). Immediate post-concussion assessment and cognitive testing (ImPACT) practices of sports medicine professionals. *Journal of Athletic Training, 44(6),* 639-644.

Covassin, T., Moran, R., & Wilhelm, K. (2013). Concussion symptoms and neurocognitive performance of high school and college athletes who incur multiple concussions. The American Journal of Sports Medicine, 41(12), 2885-2889.

Covassin, T., Swanik, C. B., Sachs, M., Kendrick, Z., Schatz, P., Zillmer, E., & Kaminaris, C. (2006). Sex differences in baseline neuropsychological function and concussion symptoms of collegiate athletes. *British Journal of Sports Medicine, 40*, 923-927.

Cripps, A., Livingston, S., & Desantis, B. (2016). The test- retest reliability and minimal detectable change of the sensory organization test and head- shake sensory organization test. *Journal of Sports Medicine and Allied Health Sciences: Official Journal of the Ohio Athletic Trainers Association, 2*(2) https://10.25035/jsmahs.02.02.02

Echemendia, R.J., Meeuwisse, W., McCrory, P., Davis, G.A., Putukian, M., Leddy, J., Makdissi, M., et al. (2017). The sport concussion assessment tool 5th edition (SCAT5): Background and rationale. British Journal of Sports Medicine, 51, 848-850.

Eckner, J. T., Kutcher, J. S., & Richardson, J. K. (2011). Between-seasons test-retest reliability of clinically measured reaction time in National Collegiate Athletic Association Division I athletes. *Journal of Athletic Training, 46*(4), 409-414. https://www.ncbi.nlm.nih.gov/pubmed/21944073

Eckner, J. T., Lipps, D. B., Kim, H., Richardson, J. K., Ashton-Miller, J. A. (March 2011) Can a clinical test of reaction time predict a functional head protective response? *Medicine & Science in Sports & Exercise, 43(3),* 382-387.

Finnoff, J. T., Peterson, V. J., Hollman, J. H., & Smith, J. (2009). Intrarater and interrater reliability of the balance error scoring system (BESS). *American Academy of Physical Medicine and Rehabilitation, 1, 50-54.*

FitLight Corp. Speed and agility training system for athletes. Accessed on February 29, 2020. www.fitlighttraining.com

Guskiewicz, KM., Weaver, N.L., Padua, D.A., Garrett, W.E. (2000). Epidemiology of concussion in collegiate and high school football players. *American Journal of Sports Medicine, 28(5),* 643-650.

Guskiewicz, K.M., McCrea, M., Marshall, S.W., et al. (2003). Cumulative effects associated with recurrent concussion in collegiate football players: The NCAA concussion study. *Journal of American Medical Association, 290(19),* 2549-2555.

Gutiérrez-Davila, M., Rojas, F. J., Gutiérrez-Cruz, C., & Navarro, E. (2017). Effect of dual-attention task on attack and defensive actions in fencing. *European Journal of Sport Science, 17*(8), 1004-1012. https://10.1080/17461391.2017.1332100

Ishihara, S. (1917). Ishihara Instructions. *University of Tokyo Member of the Japan Academy.*

Iverson, G.L., Echemendia, R.J., Lamarre, A.K., Brooks, B.L., Gaetz, M.B. (2012). Possible lingering effects of multiple past concussions. *Journal of Rehabilitation Research and Practice,* 2012-316575. doi:10.1155/2012/316575 [doi].

Kay, T., Harrington, D. E., Adams, R., Anderson, T., Berrol, S., Cicerone, K., Dahlberg, C., Gerber, D., Goka, R., Harley, P., Hilt, J., Horn, L., Lehmkuhl, D., & Malec, J. (1993). Definition of mild traumatic brain injury. *Journal of Head Trauma Rehabilitation, 8*(3), 86-87. https://10.1097/00001199-199309000-00010

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *The Journal of Chiropractic Medicine, 15, 155-163.*

Langlois, J. A., Rutland-Brown, W., & Wald, M. M. (2006). The epidemiology and impact of traumatic brain injury: a brief overview. *The Journal of Head Trauma Rehabilitation, 21*(5), 375-378. https://10.1097/00001199-200609000-00001

Lee, J. H., Howell, D. R., Meehan, W. P., & Gardner, A. J. (2017). Effects of exercise on sport concussion assessment tool-third edition performance in professional athletes. *The Orthopedic Journal of Sports Medicine, 5(9)*, 1-7.

Lempke, L. B., Howell, D. R., Eckner, J. T., & Lynall, R.C. (2020). Examination of reaction time deficits following concussion: A systematic review and meta-analysis. *Sports Medicine, 50, 1341-1359.*

Louey, A.G., Cromer, J.A., Schembri, A.J., Darby, D.G., Maruff, P., Makdissi, M., & McCrory, P. 2014. Detecting cognitive impairment after concussion: Sensitivity of change from

baseline and normative data methods using the CogSpot/Axon cognitive test battery. *Archives of Clinical Neruopsycology, 29,* 432-441.

MacDonald, J., & Duerson, D. (2015). Reliability of a computerized neurocognitive test in baseline concussion testing of high school athletes. *Clinical Journal of Sports Medicine, 25(4),* 367-372.

MacDonald, J., Wilson, J., Young, J., Duerson, D., Swisher, G., Collins, C., & Meehan, W. (2015). Evaluation of a simple test of reaction time for baseline concussion testing in a population of high school athletes. *Clinical Journal of Sport Medicine, 25*(1), 43-48. https://10.1097/JSM.0000000000000096

Mannix, R., Iverson, G.L., Maxwell, B., Atkins, J.E., Zafonte, R., Berkner, P.D. (2014). Multiple prior concussions are associated with symptoms in high school athletes. *Journal Annals of Clinical and Translational Neurology, 1(6),* 433-438.

McInnes, K., Friesen, C. L., MacKenzie, D. E., Westwood, D. A., & Boe, S. G. (2017). Mild Traumatic Brain Injury (mTBI) and chronic cognitive impairment: A scoping review. *PloS One, 12*(4), 1-19. https://10.1371/journal.pone.0174847

Mullally, W. J., MD. (2017). Concussion. *The American Journal of Medicine, 130*(8), 885-892. https://10.1016/j.amjmed.2017.04.016

National Institute of Neurological Disorders and Stroke. (2019). *Traumatic Brain Injury Information Page.* https://www.ninds.nih.gov/Disorders/All-Disorders/Traumatic-Brain-Injury-Information-Page

Nelson, L. D., LaRoche, A. A., Pfaller, A. Y., Lerner, E. B., Hammeke, T. A., Randolph, C., Barr, W. B., Guskiewicz, K., & McCrea, M. A. (2016). Prospective, head-to-head study of three computerized neurocognitive assessment tools (CNTs): Reliability and validity for the assessment of sport-related concussion. *Journal of the International Neuropsychological Society, 22(1)* 24-37.

Perroni, F., Mol, E., Walker, A., Alaimo, C., Guidetti, L., Cignitti, L., & Baldari, C. (2018). Reaction time to visual stimulus in firefighters and healthy trained subjects: A preliminary comparative study. *The Open Sports Sciences Journal, 11*(1), 69-77. https://10.2174/1875399X01811010069

Rauter, S., Coh, M., Vodicar, J., Zvan, M., Krizaj, J., Simenko, J., Szmajda, L., & Mackala, K. (2018). Analysis of reactive agility and change-of-direction speed between soccer players and physical education students. *Human Movement, 19*(2), 68-74. https://10.5114/hm.2018.74061

Reigal, R. E., Barrero, S., Martín, I., Morales-Sánchez, V., Juárez-Ruiz de Mier, R., & Hernández-Mendo, A. (2019). Relationships between reaction time, selective attention, physical activity, and physical fitness in children. *Frontiers in Psychology, 10*, 2278. https://10.3389/fpsyg.2019.02278

Staden, D. V., Mahomed, F. N., Govender, S., Lengisi, L., Singh, B., & Aboobaker, O. (2018). Comparing the validity of an online Ishihara colour vison test to the traditional Ishihara handbook in a South African university population. *African Vision and Eye Health, 77 (1).* https://avehjournal.org/index.php/aveh/article/view/370/770

Stratford, P.W. (2004). Getting more from the literature: Estimating the standard error of measurement from reliability studies. *Physiotherapy Canada, 56, 27-30.*

Straume-Naesheim, T.M., Andersen, T.E., & Bahr, R. 2005. Reproducibility of computer based neuropsychological testing among Norwegian elite football players. British Journal of Sports Medicine, 39 Suppl 1 (supple 1), i64-i69.

Thomas, D. G., Collins, M. W., Saladino, R. A., Frank, V., Raab, J., & Zuckerbraun, N. S. (2011), Identifying neurocognitive deficits in adolescents following concussion. *Journal of the Society for Academic Emergency Medicine, 18,* 246-254.

Torres, D. M., Galetta, K. M., Phillips, H. W., Dziemianowicz, E. M. S., Wilson, J. A., Dorman, E. S., Laudano, E., Galetta, S. L., & Balcer, L. J. (2013). Sports-related concussion: Anonymous survey of a collegiate cohort. *Neurology. Clinical Practice, 3*(4), 279-287. https://10.1212/CPJ.0b013e3182a1ba22

Verschueren, J., Tassignon, B., Pluym, B., Van Cutsem, J., Verhagen, E., & Meeusen, R. (2019). Bringing context to balance: development of a reactive balance test within the injury prevention and return to sport domain. *Archives of Physiotherapy, 9*(1), 6. https://10.1186/s40945-019-0057-4

Walton, C. C., Keegan, R. J., Martin, M., & Hallock, H. (2018). The potential role for cognitive training in sport: More research needed. *Frontiers in Psychology, 9*, 1-7. https://10.3389/fpsyg.2018.01121

Wolf, C. J., & Fast, K. (2017). "Put me back in, coach!" Concussion and return to play. *University of Missouri Health School of Medicine, 114*(1), 36-39.

Yen-Hsiu Liu, Lai-Chu See, Shih-Tsung Chang, Jiahn-Shing Lee, Li-Chuan Shieh, Yu-Lin Ning, Ai Yin Lim, & Wei-Min Chen. (2018). Simple and choice response time among elite and novice karate athletes and non-athletes. *Archives of Budo, 14*, 267-276

APPENDIX A
INFORMED CONSENT FORM

BOWLING GREEN STATE UNIVERSITY

School of Human Movement, Sport, & Leisure Studies

214 Eppler South Complex
Bowling Green, Ohio 43403-0280
419-372-0221

http://www.bgsu.edu/colleges/edhd/hmsls/index.html

Informed Consent for "Test Re-test Reliability of the FitLight Trainer™"

Key Information:

This study is being conducted by graduate student Lauren Myers with assistance from Dr. Andrea Cripps and Dr. Jenny Toonstra, Assistant Professors of Athletic Training at Bowling Green State University. We are inviting you to participate in a research study. The purpose of this study is to determine the reliability of a new piece of equipment called the FitLight Trainer™. The results of this study will help us to establish training protocols that can be used clinically. Your involvement in this study would consist of you coming to Eppler South 107 for two sessions. The first session would take about 20 minutes and the second would take about 10 minutes. You would be asked to complete a task where you move your hands to a target as fast as you can to deactivate a series of eight LED lights. There is minimal risk involved in this study. As researchers, we will not share your name or anyone else you name (coaches, teammates, friends, and/or family) with anyone. Your participation in this study is voluntary.

Introduction:

My name is Lauren Myers, and I am a graduate student in the School of Human Movement, Sport & Leisure Studies at Bowling Green State University. My advisors are Dr. Andrea Cripps and Dr. Jenny Toonstra who teach in the Athletic Training Program in the School of Human Movement, Sport & Leisure Studies at Bowling Green State University. Our research topic is the reliability of the FitLight Trainer™. You are being asked to participate in this research study because you are a college student between the ages of 18-24 and have not had a concussion or the presence of post-concussion symptoms within the last 6 months.

Purpose:

The purpose of this study is to determine the reliability of a new piece of equipment called the FitLight Trainer™. You will receive no direct benefit from participating in this study other than adding to the body of knowledge. However, you will be given your performance results (choice reaction time) following the conclusion of the study.

Procedure:

Your involvement in this study includes participating in two 10-20-minute sessions in Eppler South 107. You will be asked some general demographic information (height, weight, sex, hand dominance) and then you will be shown to the testing location. You will be allowed to complete a practice trial to become familiar with the equipment that will be used during testing. When the testing

begins you will be standing in front of a series of eight discs that light up in different colors. You will be instructed to touch the target with your hand only when the green color comes on the disks and ignore any other colors that might appear. You will be asked to complete 20 attempts per trial. You will then be given a short break before completing a second trial which will be a little faster than the first. You will be given a short break and then complete a third trial. After you are done with testing you will arrange your second follow-up session for seven days later.

Participation and Benefits:

Your participation is completely voluntary. You are free to withdraw at any time. You may decide to not answer a question or discontinue participation at any time without explanation or penalty. Your decision whether to participate will not affect your relationship with Bowling Green State University in any way. Following the conclusion of the study, you will be given a $10 gift card for your participation.

Confidentiality Protection:

This consent form will be stored in a locked drawer in Dr. Cripps' office. At the completion of the study, these files will be physically shredded. All information related to this study will be kept on a password protected computer for three years and then it will be electronically destroyed. Only Dr. Cripps, Dr. Toonstra and I will have access to this information. We may use any information collected from you for future research, but only after your personal information has been removed.

COVID-19 Safety Protocols:

To comply with state and university ordinances regarding the novel Corona Virus, additional safety and health measures will be implemented to ensure the well-being of all participants and researchers involved. All testing procedures will be conducted in a laboratory space that has been set up with the appropriate social distancing measures of six feet. Prior to testing and in between participants, all high touch point surfaces and equipment will be disinfected. Before arriving to the laboratory, participants will be asked to complete the personal health/wellness check based on CDC and ODH guidelines. If exhibiting symptoms, participants will be asked not to come in and to contact their medical provider immediately. During testing, participants and the researcher will be required to wear a face covering that covers both the nose and mouth completely, at all times and appropriate social distancing measures will be implemented when possible.

Risks:

As a result of participating in this study, there is a minimal risk to you such as hurting your finger or hand from incorrectly touching the light.

Contact Information:

For any questions about the research or your participation in the research, you can contact Lauren Myers at myerslr@bgsu.edu or Dr. Andrea Cripps at acripps@bgsu.edu or 419-372-0221 or Dr. Jenny Toonstra at jltoons@bgsu.edu or 419-372-4429. You may also contact the Chair of the Bowling Green State University Institutional Review Board, at 419-372-7716 or orc@bgsu.edu, if you have any questions about your rights as a participant in this research.

Statement of Consent:

I have been informed of the purposes, procedures, risks and benefits of this study. I have had the opportunity to have all my questions answered and I have been informed that my participation is completely voluntary. I agree to participate in this research.

_____

Printed Name of Participant

_____ _____

Participant Signature Date

APPENDIX B
DEMOGRAPHIC QUESTIONS

ID Code _____

Based on initials and birth date: first initial, last initial, two-digit month, two-digit date. For example: Freddie Falcon's birthday is June 1. Freddie's ID code would be FF0601.

Age: _____

Sex: Male ☐ Female ☐ Prefer not to disclose ☐

Height: _____

Weight: _____

What is your dominate hand (what hand do you write with)?: _____

APPENDIX C
RECRUITMENT FLYER

Are you interested in learning your choice reaction time and accuracy?

Researchers in BGSU's School of Human Movement, Sport & Leisure Studies are interested in determining the reliability of a newly acquired piece of equipment called the FitLight Trainer®. By determining the reliability of this equipment, we hope to be able to use this equipment to improve reaction speed and accuracy. **Participants who complete all testing procedures will be given a $10 gift card to Dunkin Donut.**

If you are interested in participating, please contact:

Lauren Myers (myerslr@bgsu.edu) OR

Dr. Andrea Cripps (acripps@bgsu.edu, 419-372-0221) OR

Dr. Jenny Toonstra (jltoons@bgsu.edu, 419-372-4429)