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## A Literature Review: Applied Behavior Analysis and Performance; the Past, the Present, and the Future

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**A LITERATURE REVIEW: APPLIED BEHAVIOR ANALYSIS AND PERFORMANCE;  
THE PAST, THE PRESENT, AND THE FUTURE**

A Master's Thesis

Presented to

The Graduate College of  
Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Applied Behavior Analysis

By

Molly Patrice Fields

December 2020

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# **A LITERATURE REVIEW: APPLIED BEHAVIOR ANALYSIS AND PERFORMANCE; THE PAST, THE PRESENT, AND THE FUTURE**

Psychology

Missouri State University, December 2020

Master of Science

Molly Patrice Fields

## **ABSTRACT**

Applied Behavior Analysis (ABA) and sports performance has been a topic of research since as early as the 1960s. ABA principles and interventions have been used all over in sports from enhancing athlete performance on the field, court, or course, sportsmanlike behaviors off the field, court, or course, and even looking into coaching behaviors. The purpose of this paper is twofold; to assess and analyze the current research for applied behavior analysis and sports and to use what literature is already established and systematically set the framework for future avenues of research and support a strong insert of applied behavior analysis into the world of sports as a whole. Eight sports, “sports performance” being used as an umbrella search, and 11 behavior analytic procedures were chosen to narrow down searches for applied behavior analysis and sports performance. The two databases used to identify articles were GoogleScholar and PYSCinfo. I identified 22 articles that met the inclusion criteria. With the specific sports and sports performance as an umbrella search term, 10 sports were included as well as 11 behavior analytic procedures, though two were different from the original 11 used to narrow the searches. In addition, 40 target behaviors were identified in the 22 articles included. The Seven Dimensions were also assessed within the 22 included articles. The *applied*, *behavioral*, *analytic*, and *conceptual systems* dimensions were met in all 22 articles. Only three articles did not meet the full criteria for *effective*. *Generality* was only provided or sought in eight of the 22 included articles, and there was only one article that did not meet the *technological* criteria. Future research in this area will be discussed.

**KEYWORDS:** applied behavior analysis, sports performance, improved performance, performance enhancement, Seven Dimensions of Applied Behavior Analysis

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In the interest of academic freedom and the principle of free speech, approval of this thesis indicates the format is acceptable and meets the academic criteria for the discipline as determined by the faculty that constitute the thesis committee. The content and views expressed in this thesis are those of the student-scholar and are not endorsed by Missouri State University, its Graduate College, or its employees.

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## INTRODUCTION

### **Applied Behavior Analysis and Performance Training**

In 1938, Skinner introduced both radical behaviorism and experimental analysis of behavior (EAB), both of which were the beginnings in the world of behaviorism. One part that behavior analysts who work in the field of experimental analysis of behavior look into is what Skinner called operant behavior. Miltenberger (2004) defined operant behavior as behavior that produces a consequence and in return is strengthened or weakened by that consequence (Miltenberger, 2004). Cooper, Heron, and Heward (2007) state that Skinner's most significant contribution to behaviorism was his discovery and the analysis of consequences' effect on future behaviors (Cooper, Heron, & Heward, 2007). Skinner discovered a three-term contingency that later behavior analysts coined as a new paradigm in behaviorism (Kimball, 2002). Experimental behavior analysts mostly work in laboratories with both human and nonhuman subjects to discover and study fundamental knowledge of behavior. Skinner (1966) identified criticism in his found analysis of behavior. The criticism, per Skinner, usually includes that it is oversimplified, that it ignores facts, and that certain exceptions allow for assumptions that analysis of behavior is not enough (Skinner, 1966).

Behavior analysts working in the field of applied behavior analysis (ABA) focus on behaviors that society deems important, or valid, rather than studying for the sake of enhancing the field of ABA (Baer, Wolf, & Risley, 1968). Socially significant behaviors are defined by Baer, Wolf, and Risley as behaviors that society views as problems or things needing a change (Baer, Wolf & Risley, 1968). Both EAB and ABA do hold their individual, but similar, fields of research to a high standard in using foundational and technical practices and technologies, which

makes them interrelated with one another. The discovery of experimental analysis of behavior allowed applied behavior analysis to evolve into what current day behavior analysts practice.

Cooper, Heron, & Heward (2007) defined applied behavior analysis as “the science in which tactics derived from the principles of behavior are applied systematically to improve socially significant behavior and experimentation is used to identify the variables responsible for behavior change” (Cooper, Heron & Heward, 2007, p. 20). Though applied behavior analysts began to make their way into science as early as the late 1940s, two events occurred in 1968 that would forever change the way science viewed applied behavior analysis. First, the *Journal of Applied Behavior Analysis* (JABA)’s first publication was released. The first articles in JABA helped behavior analysts lead the way in applied behavior analysis and acted as models for research to follow. Second, Baer, Wolf, and Risley (1968) published “Some Current Dimensions of Applied Behavior Analysis.” Modern behavior analysts later titled Baer, Wolf, and Risley (1968) as the founding fathers of applied behavior analysis and credited them for setting the standard for this new discipline of science.

Applied Behavior Analysis is defined by the Seven dimensions of ABA to ensure research falls accurately under “applied behavior analysis”. The Seven Dimensions are as follows: applied, behavioral, analytic, technological, conceptual, effective, and generality (Baer, Wolf, & Risley, 1968). To meet the definition of *applied*, the behavior analyst must choose a behavior deemed important to society, behaviors that can make a difference in the world and add quality to people’s lives. Research that happens in natural settings, rather than laboratory settings, also falls under *applied*.

To meet the expectation of *behavioral*, applied behavior analysts must use behaviors both observable and measurable. Applied behavior analysts do not study the person as a whole, but

the behavior(s) of that individual (Baer, Wolf, & Risley, 1968). Baer, Wolf, and Risley (1968) next identified *analytic* as another dimension. For applied behavior analysis to fall under analytic, the interventions used in research must account for the change in behavior, whether it is an increase, decrease, or maintenance of the behavior. Baer, Wolf, and Risley (1968) point out that similarly to experimental psychology, applied behavior analysts have successfully demonstrated the *analytic* dimension when the experimenter displays control over the behavior.

The next of Seven Dimensions is *technological*. Behavior analysts meet the criteria for *technological* by documenting and doing their research in a way that future behavior analysts can replicate. Behavior analysts must document thoroughly in their research to allow the possibility for replication. As said by Baer, Wolf, and Risley (1968), technological means that "... techniques making up a particular behavioral application are completely identified and describe." Behavior analysts rely on replication, just as in experimental analysis. Behavior analysts' ability to replicate allows for theories to transition to empirical. The next dimension, *conceptual systems* ties in very closely with *technological*. Conceptual systems require behavior analysts to use applications and practices that are empirical in nature and have data to support their effectiveness in Applied Behavior Analysis. Examples of these applications or practices may be using token economies, reinforcement, PECS as an alternative communication system for typically non-verbal individuals, etc.

The last two of the Seven Dimensions are *effective* and *generality*, both of which Baer, Wolf, and Risley (1968) identified as greatly important (Baer, Wolf, & Risley, 1968). The use of behavioral practices must produce a large enough effect to make a difference and therefore qualify as effective. Whether the behavior analysts have a goal to decrease an undesirable behavior or increase a desirable behavior, the intervention must increase or decrease the behavior

enough to create a noticeable difference. Baer, Wolf, and Risley (1968) defined *effective* as “producing a large enough effect for practical value.” Behavior analysts claim some subjectivity as to what constitutes as a large enough effect or practical value, as behavior analysts have no known or established value for either of the two. Baer, Wolf, and Risley (1968) also notate that those surrounding the individual in their natural settings identify whether or not a large enough effect has been made (e.g., family, teachers, etc.).

Behavior analysts prove *generality* when a changed behavior can stand the test of time. Generality could also describe a behavior across settings as well. It is often assumed that generalization directly notes the success of a behavioral application on a behavior; in short, where there is generalization, there was success (Baer, Wolf, & Risley, 1968). It is important to recognize that generalization should not be assumed as a result of using a behavioral application. Baer, Wolf, and Risley state that behavior analysts should strategically plan and place generalization into the intervention, as behavior analysts cannot assume generalization will occur independently. Thus, applying behavioral change across time and settings can create a better environment for the individual in which the application was intended for, as well as those surrounding that individual and the behavior.

Critchfield and Reed (2017) wrote extensively on the Seven Dimensions of Applied Behavior Analysis and their “Fuzzy Concept”. Critchfield and Reed (2017) presents the concept that the seven dimensions were based on the transition of ABA within a laboratory setting into natural settings in accordance with socially valid behaviors. Critchfield and Reed (2017) reason that the dimensions, as normal rules of engagement, certainly differ between social issues, or within studies. Baer, Wolf, and Risley (1968) assert that effectiveness is determined by those surrounding the individual in which the study is being conducted. Therefore, it could be assumed

that two individuals in separate studies with the same socially valid problem could have different conclusions of effectiveness, deterring outside of the dimensions. Critchfield and Reed (2017) support the idea that there may be a strong case in thinking about studies/research outside of the renowned Seven Dimensions of ABA established by Baer, Wolf, and Risley in 1968. In turn, looking at ABA research as a “fuzzy concept” rather than the firm boundaries in place by the Seven Dimensions of ABA could expand the bounds of ABA research (Critchfield and Reed, 2017).

Applied behavior Analysis and Developmental Disabilities have a long history with one another, ranging as far back at the 1940s. Developmental disabilities are a medical diagnosis in which an individual is developing at an atypical rate, which is typically slower than normal. Medical doctors diagnose developmental disabilities and can often do so when the individual is at a young age, as there are typically early indicators in a child’s life that they are not developing at a normal rate, whether that be in comparison to an older sibling or peers/classmates in daycare or school. Applied Behavior Analysis is a field that has been moved towards working with individuals with developmental disabilities in response to supporting research in ABA involving learning processes and language development.

Neef highlighted each decade from the 1940s to the present in her 2001 work. During the 1940s, Skinner had scratched the surface with behaviorism. Though at this time no relation between behaviorism and developmental disabilities occurred, the world of developmental disabilities was stuck in a model where society viewed those with developmental disabilities as a loss, essentially. Society had thought individuals with developmental disabilities could not learn, or were unteachable, and therefore no training or education was attempted. (Neef, 2001).

The 1950s brought a vast change in thinking for individuals with developmental disabilities. Authors in the field began doing a great degree of research, which allowed the members of society with developmental disabilities to no longer hold that stereotype or label. Neef states that at this time, “persons with disabilities and mental illness contributed more to behavior analysis than behavior analysis benefited them during this time” (Neef, 2001, p. 336). The 1950s set the stage for the interaction between behavior analysis and developmental disabilities. Then the 1960s established that individuals with developmental disabilities were, in fact, capable of learning and that behavior repertoires could be taught. (Neef, 2001.)

Currently, applied behavior analysis/ major role enhanced the field of developmental disabilities, but undoubtedly the field of developmental disabilities benefitted from the growth of applied behavior analysis. To this day, applied behavior analysis still plays its largest role in the world of developmental disabilities and has added the scope of autism along the way.

### **Sports Performance as a Measurable and Socially Valid Behavior**

Behaviors can broadly be described as anything and everything living things do. Those behaviors could be physical activity, speaking, singing, or even thinking. Johnston and Pennypacker (1993) formulated a complete definition of behavior. This definition is as follows: “The behavior of an organism is that portion of an organism’s interaction with its environment that is characterized by detectable displacement in space through time of some part of the organism and that results in a measurable change in at least one aspect of the environment (Johnston and Pennypacker, 1993, p. 23).

Behaviors exist in the realm of sports within participating in the sport itself, on the bench, in coaching decisions, and even by the audience. A behavior as simple as scoring points, throwing a

ball, hitting a ball, throwing a strike, blocking the defense, making free throws, and running are all examples of behaviors in sports. Most behaviors in sports require a skillset particular to that sport, or even a skillset that athletes can transfer between sports (e.g., running). Most of the skillsets and techniques in sports can also be broken down into behaviors, which are often goals within play as well as end goals (e.g., scoring points, hitting homeruns, scoring touchdowns, etc.). Martin, Thompson, and Regehr (2004) conducted a literature review and identified 17 sports that had been included in research as early as 1977 (Martin, Thompson, & Regehr, 2004). Schenk and Miltenberger (2019) later published another literature review, identifying 21 sports in their review (Schenk & Miltenberger, 2019). In fact, applied behavior analysis and sports performance research goes as far back as 1974 with “Effects of Self-Recording on Attendance and Performance in a Competitive Swimming Training Environment” (McKenzie & Rushall, 1974).

In 2015 James Luiselli and Derek Reed wrote a chapter in *Clinical and Organizational Applications of Applied Behavior Analysis* covering research already completed in applied behavior analysis and sports performance. Luiselli and Reed reported to have selected sports that have the largest research base or have promising results (Luiselli and Reed, 2015). However, the promising results create the opportunity to expand research with new avenues in applied behavior analysis and sports performance. Two examples of research avenues to explore further are sports performance with individuals with intellectual or developmental disabilities and generalization/generalizability from practice performance into game performance, which Luiselli and Reed touch on very briefly in their 2015 work. However, a handful of studies in Luiselli and Reed make the future in the field of applied behavior analysis and sports performance very promising from youth sports up to college athletics.

Luiselli and Reed highlighted a study completed by Ward and Carnes in 2002 with five linebackers at a Division II College Football team. In this study, Ward and Carnes used goal setting and public posting to improve “reads”, “drops”, and “tackles.” Ward and Carnes coded these three skills as either correct or incorrect, then converted the number of correct trials into a percentage (Ward & Carnes, 2002). All five linebackers were told to set goals, all of which set their goal at 90% correct execution for all three target behaviors. The public posting included a chart hung up in the locker room displaying the daily practice results. Neither implementation was used during games, only practice. Baseline ranged from 60% to 80% for all players. During the intervention, the percentage of correct execution increased to 90%-100%.

Luiselli and Reed highlighted another study conducted by Allen in 1998. Allen didn't look at increasing or decreasing physical performance in sports but reducing “negative behavior” (Luiselli and Reed, 2015). The participant was a 14-year-old tennis player with a history of unsportsmanlike conduct. Some of the specific behaviors included loud vocalizing, striking racket on the court, and waving arms during matches. Parents reported that they had failed to decrease these outbursts. The training implemented included the boy having to identify what his outburst looked like, what precursors looked like, and what most commonly caused the outbursts. Allen taught breathing, and later put a response cost system into place after the above combination of procedures reduced the number of outburst but did not reduce them to an acceptable frequency. The response cost system nearly eliminated the outburst, for if he had an outburst, the boy would have to withdraw from the match he was playing in, then would have to forfeit his next match. The author of this study completed a 12 month follow up and the parents reported the outburst returned, but at a much lower intensity.

Osborne, Rudrud, and Zezoney (1990) studied five collegiate baseball players and the use of visual cues to improve hitting curveballs. Using a pitching Initially the authors used unmarked balls, then they added two different marked sets of baseballs with the unmarked baseballs. Researchers recorded percentage of “well-hit” balls using criteria that included distance, location, and swing. Results showed that using the visual cues increased the ability to hit the unmarked balls well. The researchers noted that the ultimate goal would be to fade the visual cues from “high-level prompts to naturally occurring levels” (Osborne, Rudrud, and Zezoney, 1990, p. 376).

Above are just some examples of the operational definitions for sport specific behaviors. Baseball encompasses a handful of different behaviors that make up how the players play the game of baseball. A common behavior in baseball is a batter hitting the baseball. A batter must hit the ball in fair play, otherwise known as between the foul lines. Therefore, an operational definition for “hitting the ball” would be contacting the baseball by swinging the bat and the ball landing in fair territory. Another behavior in baseball is pitching a strike. The operational definition for pitching a strike could be the pitcher throwing the baseball from the pitcher’s mound towards home plate in which the ball travels to the catcher through the strike zone without the batter swinging, the batter swinging and missing, or a foul ball without a field player catching the ball out of the air before the ball hits the ground. Researchers can easily observe and measure these operational definitions, also allowing for replication in future research.

Football is another sport that exhibits numerous behaviors in which researchers can operationally define. Researchers have identified scoring touchdowns, getting a first down, catching the football, blocking, throwing a complete pass, and more behaviors in football. Researchers could define the quarterback throwing the football to a member of the offense and

that member of the offence using his/her hands or bodies to gain, then maintain control of the ball before the ball hits the ground or is intercepted by a member of the defense as a complete pass. Scoring a touchdown could be defined as a member of the offense taking the football across the goal line by either running the ball or the quarterback throwing a complete pass in the end zone and the receiver maintaining control of the ball within bounds.

Schenk and Miltenberger (2019) published a literature review that encompassed 101 studies starting in 1974. They only used two inclusion criteria: researchers had to use behavioral intervention and use observable and sports performance based target behaviors. They excluded any studies that authors defined as “therapeutic”, were part of an organized sport, or if written in other languages than English (Schenk and Miltenberger, 2019). Their findings included 21 sports, 23 behavioral interventions, and just over 1,500 participants amongst the 101 studies (Schenk and Miltenberger, 2019). Schenk and Miltenberger (2019) recognized research on sports performance and ABA, however Martin, Thompson, and Regehr (2004) wrote an earlier comprehensive literature analysis (Schenk and Miltenberger, 2019). Schenk and Miltenberger (2019) expanded on their literature review, using fewer inclusion criteria than Martin, Thompson, and Regehr (2004).

### **Foundational Learning Processes Underlying Performance**

Cooper, Heron, & Heward (2007) defined shaping as “differentially reinforcing successive approximations toward a terminal behavior” (Cooper, Heron, & Heward, 2007, p, 421). A terminal behavior is another term for the end goal, or the behavior the individual is working towards. Both successive approximations and differential reinforcement are essential for successful shaping. There is no standard for how many successive approximations are required.

That number is dependent upon the individual and the prerequisite skills they have for whichever terminal behavior they are shaping towards. Shaping could be used in many different sports for many different skills.

Slocum and Tiger (2011) explained chaining in their article, *An Assessment of the Efficiency of and Child Preference for Forward and Backward Chaining*, assessed articles using forward and backward chaining as well as defining both. Chaining is defined as breaking a task into its separate parts and using a task analysis to teach each part until each part is mastered and the task can be completed as a whole. Slocum and Tiger add that prompting and differential reinforcement is used to master each part of the task (Slocum & Tiger, 2011, p. 793). Forward chaining uses the chaining process starting with the first step in the task analysis and moving forward with every step mastered. Backward chaining involves starting with the final step in the task analysis and moving backwards toward the initial step in the task.

Reinforcement is described as a “basic operant functional relation” (Michael, 2004, p. 30). This relation being that when a behavior is followed by reinforcement, the behavior is likely to occur again in the future. Reinforcement can be both positive and negative reinforcement. It should be noted that “positive reinforcement” and “negative reinforcement” are often mistaken by the common connotations of “positive” and “negative.” Positive reinforcement simply means a stimulus is presented after a response is emitted, whereas negative reinforcement refers to the removal, termination, reduction, or postponement of a stimulus after a response (Cooper, Heron, & Heward, 2007, p. 292). Both, though, still result in the increased frequency of that response in the future. Punishment acts as the exact opposite of reinforcement. Punishment is the presentation or removal of a stimulus after a response in which will likely decrease the frequency of that response in the future.

Hayes heavily highlighted mindfulness with his introduction of ACT in 1968. Harris, in his work “Embracing Your Demons: An Overview of Acceptance and Commitment Therapy”, offers some examples of the examples of mindfulness. Some of these include being present, being a part of what is right now and right here and staying there, allowing feelings to be just that, and to try and let go of controlling feelings (Harris, 2006). These three topics belong to one of the two subsections of the ACT matrix that are commitment and behavior change processes. The other subsection of ACT contains acceptance, defusion, and self as context, known as the mindfulness and acceptance-based processes. The six total ACT recognizes the behaviors that observers cannot see or hear, but the “private experiences”, even the painful or unpleasant ones.

Prompts and prompt fading are another practice used in applied behavior analysis that not only has promising research for its validity, but also promising in that expanding to sports could have benefits. Seaver and Bourret in 2014 evaluated using prompts to teach behavior chains. Three types of prompts evaluated were vocal instructions, modeling, and physical guidance. Modeling is defined by Cooper, Heron, & Heward as demonstrating the desired behavior as a prompt (Cooper, Heron & Heward, 2007, p. 402). Seaver and Bourret found that their results showed “idiosyncratic differences in sensitivity to response prompts and prompt-fading procedures” (Seaver and Bourret, 2014, p. 789). These results could prove promising in sports, as each player or athlete may be differentially receptive to certain prompts that their teammates may not be.

Goal setting is a systematic process in which objectives are set to achieve a greater goal. Goal setting can be done in a controlled setting with an outside person managing the goal attainment, or can be self-managed/monitored. Bower and McLellan did a study in 1994 using goal setting with children who had a diagnosis of Cerebral Palsy to increase motor skills. Overall

this study was promising in using goal setting, but Bower and McLellan did assess that the children who did not tolerate treatment well could have had goals that were “too difficult or incomprehensible” (Bower & McLellan, 1994, p. 204). This creates the importance of creating goals that are individualized, attainable, and are monitored through the attainment process.

### **Third Wave Underlying Behavior Analysis and Performance**

ACT has played a very prominent role in the Third Wave of Behavior Analysis. ACT is an acronym that stands for Acceptance and Commitment Therapy and was created by Steve Hayes in 1986. Russell Harris in his 2006 work, “Embracing Your Demons: An Overview of Acceptance and Commitment Therapy”, Harris states that “the goal of ACT is to create a rich and meaningful life, while accepting the pain that inevitably goes with it” (Harris, 2006, p. 2).

ACT allows for treatment plans to be very individualized for whomever uses it with the assumption that all people have different experiences and is not designed for to goal of “symptom reduction” (Harris, 2006, p. 3). The goal is to become comfortable with your thoughts and past experiences and not look at them as obstacles, or negatively. The intervention narrows in on two main processes: accept unwanted thoughts and feelings without trying to control them and to live your most meaningful life (Harris, 2006, p. 5). In ACT, the word “mind” is used synonymously with “human language” (Harris, 2006, p. 4).

ACT possesses six main processes that make up the intervention. These six principles are defusion, acceptance, contact with the present moment, the Observing Self, values, and committed action. The goal and idea behind defusion are to separate our actions from our thoughts, allowing little to no influence from our thoughts. ACT views thoughts as nothing more than language and encourages from making them anymore than that. Acceptance allows for the

individual to experience negative thoughts and cognitions head on and accept that those thoughts and cognitions are just what they are instead of avoiding or running from them. Contact with the present moment means coming to terms with “the here and now.” The focus in this principle is to not worry about what stressors might have occurred in the past, nor what may come in the future, just what is here now.

The Observing Self is recognizing yourself as you are and separate from your thoughts and cognitions. Harris states that thoughts are not what make you up as a whole person, that they are just a part of you (Harris, 2006). The fifth principle is values. During this part of intervention, it is important for the individual to decide what is important to he or she, what could make their life meaningful or of better quality. The final principle is committed action. This step of intervention is guided by the values identified in principle number 5 and taking the initiative to ensure those values are put into practice in the individual’s life.

Each process is displayed/presented on a matrix, also known as the hexaflex diagram. This matrix and hexaflex represents the transition from psychological inflexibility to psychological flexibility (Wilson, 2014). The left side includes non-acceptance (or experiential avoidance), fusion, and self as context. Each of these having an opposite, which are the ultimate goal of ACT along with moving to the right side of the hexaflex. Those opposites are acceptance, defusion, and self as context versus self as content. The right side of the matrix/hexaflex fall into a subsection known as commitment and behavior change processes. This subsection includes present moment, values, and committed action. Reaching the right side of the matrix/hexaflex means an individual has reached psychological flexibility. ACT itself is flexible in that it can be used in many settings, with many populations, and with many different target behaviors using the ACT processes.

ACT absolutely could make its way into sports performance. In sports, athletes of all ages, divisions, and Leagues experience a plethora of “negative” experiences, thoughts, emotions, etc. and are expected to quickly turn around and perform to the highest of levels. Athletes experience injuries (minor, major, career ending), failures in performance, poor relationships with coaches, managers, teammates, and more. Not to mention athletes have a personal life to maintain outside of on the field, court, or course. ACT could be used individually or for teams, especially teams that have experienced trauma as a team such as a teammate’s or coach’s death, major medical diagnosis of a teammate or coach, natural disaster of the city the team resides in, and more. There is certainly an appropriate place for ACT in sports performance, as ACT not only promotes but allows for flexibility.

### **Purpose of the Present Study**

The purpose of this study is to assess and analyze the current research for applied behavior analysis and sports on two databases: Google Scholar and PYSCinfo. Five major sports were researched in the study, as well as 11 evidence-based practices implemented in applied behavior analysis. A second purpose to the study is to use what literature is already established and systematically set the framework for future avenues of research and support a strong insert of applied behavior analysis into the world of sports as a whole. Though there is evidence of research with applied behavior analysis and sports performance, there has not been enough for any level of sports and sports performance to adopt applied behavior analysis, more specifically choose an appropriate evidence-based practice, into their regular training programs. This literature review acts as an extension to Schenk and Miltenberger’s 2019 literature review, “A review of behavioral interventions to enhance sports performance”. The final purpose of this

study is to expand on Schenk and Miltenberger (2019) to include the Seven Dimensions of Applied Behavior Analysis and the most recent research, excluding any research earlier than 2000.

Major sports in America are billion-dollar industry's making sports one of the most profitable entities in the world. Contracts are made with all professional athletes with team franchises, sponsors, endorsements, etc. every year. The contracts rely on performance from that athlete. If he/she is injured, it could affect their new contract, if they choose to retire, it affects their contract, or even dishonorable actions on or off the field, court, or course can negatively impact their contracts. Point being, there is a lot of money in sports that could be used to decrease the chance of injury, increase the chance of success in one or more skill sets within a sport, or increase the frequency of desired behavior on and off the field, court, or course.

Money aside, sports are one of America's greatest past time. All year long the stands and stadiums fill up with millions and millions of people who pay to see whichever athletic event of their choice, including college athletics all the way down to hometown T-ball games. This could be said to give sports and sports performance social validity. Applied behavior analysts focuses only on social valid behaviors. Outside of the audience in major sports giving sports social validity, there are many benefits to children both with and without disabilities participating in sports.

Dykens, Rosner, & Butterbaugh in their 1998 work stated "Exercise regimens and formal sports programs such as Special Olympics are associated with improved physical fitness, reduced maladaptive behaviors, and a host of positive psychosocial effects in both children and adults with developmental disabilities" (Dykens, Rosner, & Butterbaugh, 1998, p. 768). This also adds social validity to the lowest level of sports provided in America.

Applied behavior analysis in sports could have many different shapes and sizes. It could be used, and has in past research, to decrease undesirable behavior during sports performance, increase technically sound skills within performance (which can aid in decreasing the chances of injury or increase the productivity and accuracy of performance), or increase the quality of an athlete's "mental game", which could include mindfulness and/or goal setting. Current research in applied behavior analysis and sports performance has laid a foundation, but I hypothesize there is more research needed to be able to be used successfully across all levels of sports and across all sports, not just the main and most expensive sports. These new avenues of research could incorporate the Third Wave of applied behavior analysis and be much more inclusive in terms of all sports and all levels of sports.

## METHODS

Selection of articles was completed by this author using Google Scholar and PYSCinfo. Eight sports and 11 evidence-based practices were chosen to narrow down the searches. The sports included were: football (American football, as football in other countries may be referring to what Americans know as soccer), baseball, basketball, swimming, golf, tennis, gymnastics, and volleyball. Sports performance was used as an umbrella search to capture any unspecified sports. The 11 evidence-based practices chosen were: shaping, chaining, reinforcement, punishment, mindfulness, prompts/prompt fading, modeling, public posting, behavioral skills training (BST), self-management/self-monitoring, and goal setting. These procedures were chosen as a response to initial research indicating there is current research and that they show a promising future.

Each search would include one sport and one evidence-based practice. Examples are “football and shaping”, “football and chaining”, “baseball and punishment”, and so on. Variants of these searches could also include using “&” in place of the word, “and”, the word “with” replacing the word “and”, a “+” replacing the word “and”. In addition to specific sports, “sports performance” was also used as a search term with all evidence-based practices to encompass any other research with sports that were not included in the specific sports chosen for this literature review. While using GoogleScholar, each search was filtered to not allow Google Patents and in or after the year 2000. PSYCinfo was also filtered to only allow empirical articles in or after the year 2000.

For each search, the first 50 articles were assessed using inclusion criteria determined prior to the beginning of research. This included the first 50 articles on both PYSCinfo and

Google Scholar. The inclusion criteria were a) must be an experimental study, b) did the article use a behavior both observable and measurable, and if so was the behavior identified, c) did the article use the major applied behavior analysis practice used in the search, d) was the article published in or after the year 2000, e) the study had to be in English. No exclusion was concluded if results were not positive, as the author determined negative results are just as important to note as positive results. The behavior in each article did not have to be exclusively physical or attributed to a physical skill set in the sport but had to be both observable and measurable (could include sportsmanlike behaviors outside of performance). However, behaviors had to be attributed to sports performance, so any research conducted in a physical education class or leisure exercise was excluded. Other behaviors excluded were coaching behaviors and skill acquisition.

If an article in the first 50 articles assessed matched all five inclusion criteria, the article was then analyzed and organized into a table to visually display which evidence-based practices have been researched the most. This table includes author(s) and year of article, what sport was included in the study, basic demographic information about the participants and at what level of athletics the participants perform at, what experimental design was used, what procedure(s) were used, the target behavior(s), summarized results, and whether or not follow-up was conducted (and if so, what kind of follow-up). Interobserver agreement (IOA) was conducted by having two former graduate students from Missouri State University Applied Behavior Analysis Graduate Program complete a combined 30% of the searches made by the author, each student completing 15% each independently. IOA was measured by dividing the number of agreements by the number of agreements plus disagreements. There were no disagreements found between the independent reviewers and the author, making the IOA 100%.

This author will expand on Schenk and Miltenberger (2019) by placing an additional focus on the Seven Dimensions of Applied Behavior Analysis, limiting research to sports performance behaviors and performance enhancement as a result of a behavior analysis principle or procedure, and using research no earlier than 2000. Another table will be used to identify the seven dimensions of applied behavior analysis within each of the articles included. Each dimension was explained by a short excerpt on how that article used or displayed each dimension. This differs from Schenk and Miltenberger (2019) in that any and all research done (no cap on including early research) involving ABA and sports was included, behaviors such as coaching behaviors, were included, and there was no inclusion of the Seven Dimensions of Applied Behavior Analysis. In addition, this author includes an example in the Appendix of how future research could include a written intervention program on how principles and practices of Applied Behavior Analysis could be utilized in Sports Performance or Enhancement. This could increase the integrity and validity of future research in potentially yielding longer term data with a comprehensive program.

In order to assess that a study met the criteria for each of the dimensions, there was a single inclusion criterion identified for each dimension. In order for the study to meet the criteria for *applied*, it had to be looking into a sport that was not identified as therapeutic or leisure activity. A literature review or descriptive analysis did not count as evidence for an *applied* study. A behavior that was both observable and measurable was enough evidence for a study to meet the criteria of *behavioral*. *Analytic* was evident if an experimental design was used and was responsible for the change in behavior. In order for *conceptual systems* criteria to be met, an evidence-based behavior analytic procedure had to have been used for the intervention. *Effectiveness* was simply met if there was a significant change in the behavior (in the direction

intended for it to change) and *generality* was only met if a follow-up procedure (no specific follow-up procedure) was conducted after the treatment had ended. Lastly, *technological* was judged by the author upon whether or not it could be replicated, looking for any barriers that might prevent future researchers from replicating that particular study?

## **RESULTS**

### **Overall Results**

In using the inclusion criteria and two databases identified in the methods, 22 total articles were found. Table 1 provides the 22 articles, the author(s) and year, as well as an overview of the article with the results. There were 11 procedures used in the 22 articles, six of which were used multiple times. Ten sports were also identified in the articles included, six of which were seen more than once. There were 40 target behaviors identified, some of which were specific to that article, and others that were found in more than one article (e.g., both Harrison & Pyles (2013) and Stokes, Luiselli, & Reed (2010) used tackling as their only target behavior). To go into more depth, the participants, procedure used, and experimental design used are broken down into their own section.

### **Participant Characteristics**

Within the 22 articles included in this literature review, there was a total of 354 participants. Of these 354, 170 identified as males and 182 identified as females, as well as two who chose to not disclose their gender. The age range of the 354 participants was 7-58 years of age. The participants were either recruited using inclusion criteria within the study or chosen by the author(s) and all took part in each of the interventions that were included. There were two participants out of the 169 that were not able to see the study all the way through as a result of injuries (Ste-Marie, Rymal, Vertes, & Martini, 2011). Level of athletic competition ranged from Pee Wee Football (Tai & Miltenberger, 2017) and participating in amateur tournaments (Gomberg, 2014), Olympic training program (Moore & Quintero, 2019). All studies focused on

the participants' performance with a goal of performance improvement or enhancement. Some articles included other dependent measures such as increased independent mindfulness or reduced game time anxiety, but this review focused on performance-based behaviors.

### **Procedural Characteristics**

Of the 22 studies, 11 used intervention packages and the other half (11) used a single intervention. Of the procedures used as a single intervention, mindfulness and goal-setting were most commonly used on their own (mindfulness and goal-setting used 54% of single interventions). Of the 11 procedures used to narrow down searches, 11 procedures were included in the articles two different from the 11 procedures used to narrow searches). Reinforcement was used seven times, goal setting was used five times, public posting used three times, modeling used six times, verbal instruction/prompting was used six times and mindfulness was used four times. The other procedures used only once in the included articles are shaping (Harrison & Pyles, 2013), Behavioral Skills Training (Tai & Miltenberger, 2017), self-monitoring/self-management (Schonwetter, Miltenberger, and Oliver, 2014) and chaining (Moore & Quintero, 2019).

### **Experimental Design Characteristics**

Six different experimental designs were identified in the 22 articles included in this literature review. Most common was multiple baseline across participants (45%), then multiple baseline across behaviors (23%), then multitreatment (18%), within participants (5%), and an AB and ABAC design (5%). A follow-up procedure was included only eight out of 22 studies (36%), four of which were conducted as maintenance phases after intervention, 3 of which were

conducted as follow-up data collection without the reintroduction of treatment, and one questionnaire was provided to the participants upon completion of the study. Only one out of 22 studies were not able to credit the intervention as a statistically significant control factor (Wolch, Arthur- Cameselle, Keeler & Suprak, 2020), meaning an overwhelming amount (95%) of the articles included attributed performance improvement to the procedure(s) used in the intervention. Most articles identified what experimental design they were using, though this author did have to interpret what experimental design was used on a couple of occasions.

### **Seven Dimensions of ABA Analysis**

Each article that was included in this literature review was also assessed in terms of meeting the Seven Dimensions of Applied Behavior Analysis. Table 2 provides the author(s) and year of article, then each individual dimension and how that article met the criteria of that dimension. The *applied*, *behavioral*, *analytic*, and *conceptual systems* dimensions were met in all 22 articles included. Only three articles did not meet the full criteria for *effective*. For example, in White (2017), there was only partial effectiveness as not all participants met their goals (White, 2017). Wolch, Arthur-Cemeselle, Keeler, and Suprak (2020) completed a statistical analysis to find that their procedure was responsible for a slight improvement, but not enough to be statistically significant (Wolch, Arthur-Cemeselle, Keeler, and Suprak, 2020). *Generality* was only provided or sought in eight of the 22 included articles (36%) in forms of maintenance/retention phases (Rodrigues-Neto, 2008 and White, 2017, Barzouka, Bergeles, and Hatziharistos, 2007, Zetou et al., 2002), follow-up data collection without treatment (Moore & Quintero, 2019, Boyer, Miltenberger, Batsche, & Fogel, 2009, and Bonner, 2010), as well as questionnaires (Law & Ste-Marie, 2005). There was only one instance that *technological* was

threatened and that was in Gomberg (2014) due to him being one to design the study, participate in the study and author the article. All other articles were believed to present no barriers to replication, or the *technological* dimension. Figure 1 demonstrates the number of articles each dimension was presented.

## DISCUSSION

The purpose of this literature review was to assess and analyze the current research for applied behavior analysis and sports, to use what literature is already established and systematically set the framework for future avenues of research and support a strong insert of applied behavior analysis into the world of sports as a whole, and to expand on Schenk and Miltenberger (2019) to include the Seven Dimensions of Applied Behavior Analysis and the most recent research, excluding any research earlier than 2000.

The inclusion criteria of research newer than 2000 appeared to be the largest contributor to the significantly smaller number of articles included by this author than included by Schenk and Miltenberger (2019), second being the inclusion criteria of using an experimental design. This suggests that more research is needed, and more experimental designs be used; however not discounting the contribution this literature review has made in narrowing research to this the last two decades. Along with the large number of articles that date earlier than 2000, a large number of research that was excluded were descriptive analyses and other literature reviews. As important and practical as literature reviews are in identifying the current research, the literature reviews are running thin if attempting to use as few repeated articles as has been used before.

This literature review supports the continuation of research of ABA in sports performance in providing definitive strategies to improve sports performance , as almost all of the articles included had positive results. Even in Wolch, Arthur-Cameselle, Keeler and Suprak's 2020 article that resulted in mindfulness not being statistically significant enough to be considered the control factor, there was still positive results in that the experimental group that used mindfulness made slightly more free throws than the control group that did not utilize

mindfulness (Wolch, Arthur-Cameselle, Keeler, & Suprak, 2020). Another glimmer of hope lies in the study done with 36 males participating in wheelchair basketball, recognizing that ABA and sports performance also has a place in the world of disabilities (Katarzi, Theodorakis, Tzetzis, and Vlachopoulos, 2007). There are current studies using behavior analytic procedures with children who have a diagnosed developmental or social-cognitive disorder, however those were excluded in this literature review due to skill acquisition not being categorized as sports performance. With an expansion in this specific field of study, more support could come for ABA in sports performance for all populations. As identified in the results, the procedures used were overall successful for people aged seven years old to 58 years old and across the spectrum of competing levels.

Though replication of previous work is important for future research in ABA, there is plenty of opportunity for new avenues of research and application. Though professional sports typically keep a behavior analyst or specialist on staff, that is not where the research currently lies. There is very little research, and none found in this literature review, with professional athletes. It is important to note that the participants in Moore and Quintero (2019) were not Olympic athletes but were in an Olympic training program at a local CrossFit gym (Moore and Quintero, 2019). With as much social validity as there is in professional sports, there is little research showing ABA being used at the highest level of sports performance. ABA in professional sports could encourage and market the use of ABA in sports at any level, encouraging and showing that there is always room for improvement in performance. Also marketing the flexibility in ABA and the ability for behavior analysts to adjust interventions to different demographics, sports, genders in sports, etc could assist in varying future research from what has already been researched.

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## APPENDIX

New avenues of research could also exhibit long-term studies that encompass a “program”, per se, that focuses on gradual development over the course of a longer period of time. Longer-term could mean an eight-week intervention program, versus an entire study (follow-up included) that lasts less than eight days. What could/would this look like? With having a personal experience in performing at a Division I level in softball and having started playing at six years old, I vouch for this idea of a longer-term program using ABA in sports performance. I have experienced many different coaching styles and team cultures. Currently in most sports, traveling or select sports (offered outside of sports provided by schools) are the path to college athletics. Lessons, camps, tournaments (including college exposure tournaments), and more contribute to this ultimate goal of playing a sport for a college, whatever level of college that may be. The focus that is most encouraged is typically the sports performance, or physical behaviors that make up sports performance (hitting, throwing, sliding, etc.).

However, a lot is missing from the athletics model in which mindfulness has no place. Each level of competition requires a different level of knowledge and understanding for the game, a faster reaction and stronger throw, and ability to move at the speed of performance development as teammates and peers in order to be successful. All of which are not skills of their own; they encompass many skills, both physical and mental. Whatever the level of competition, most teams lack a quality mindfulness/mental game program or focus. Incorporating mindfulness into children’s athletics would not only potentially increase the success as an older athlete, but more than likely teach and encourage the use of mindfulness in other angles of life.

Just like early intervention appears to be most successful when started at a young age with language development procedures and behavior reduction procedures, a program for an athlete started at a younger age could set the ground work for an athlete to grow to whatever level of competition that they desire. This program could include chaining and shaping, modeling, mindfulness (ACT), and goal-setting. The shaping, chaining, and modeling, alongside with mindfulness and goal-setting training, would be used in the first four weeks of an eight-week program to focus on the physical skills of the sport such as hitting a ball and throwing a ball, which are integral for both success as well as injury avoidance. These skills would be taught and would be practiced with high repetition throughout the four weeks. Shaping and chaining a task analysis resulted in increased performance by both Harrison and Pyles (2013) as well as Moore and Quintero (2019). Both self and video modeling has success stories as well (e.g., Law & Ste-Marie, 2005 and Ste-Marie, Rymal, Vertes, & Martini, 2011).

After a foundation of physical skills have been established and consistent, mindfulness and goal-setting can become the frontline focus. What tends to lack in early levels of competition of athletics is the focus on the “mental game”, which has become very popular amongst college athletic programs as well as professional athletic clubs and leagues. This would allow a young athlete to build the basic framework to begin to understand just what “mental game” means and create a possibility of a successful future in athletics.

Softball and baseball are two examples of sports that require very quick turnaround. For example, a pitcher in the batting lineup could not only strike out but be the third out with runners on second and third base. The pitcher then has a relatively short period of time to turn around and have a successful half inning of pitching. Negative thoughts (from experience) are easy to carry for long periods of time, especially if the end result is a loss in a game or match when the

opportunity presented itself. Setting up a child athlete with the basic fundamentals of being mindful and becoming an accountable goal-setter can significantly increase the chances of participating in athletics long term, and potentially very successfully.

Hypothetically, the last half of the eight-week program would decrease the intensity of focus on the shaping, chaining, and modeling (if needed to continue or reintroduce) on the physical skills, but increase the focus on mindfulness and goal-setting within the training program. Using the skills that have either been acquired or improved, mindfulness and goal-setting can be used to enhance those skills further, and possibly introduce less main physical skills in softball/baseball and more knowledge-based skills like base running (leadoffs, sliding, stance after leadoff, returning to the base).

Mindfulness or ACT exercises would be introduced with a goal of learning psychological flexibility and being in the present. As a softball or baseball player, it is fairly easy to get away from the present and either sulk in a past failure or fall into an anxious state about a future task. The goal of mindfulness in the last four weeks would be to find peace in the present, being accountable on when you are not in the present, and the ability to bring yourself to the present. Because of the easy ability to transfer the ideas of mindfulness (ACT) outside of athletics, the athlete would be encouraged to document multiple examples of how they were mindful in their week outside of training. This could be in school, at home, with friends, etc. When the athlete returned to training, the documentation of mindfulness outside of training would be shortly reviewed and discussed, and certainly reinforced when successful. The activity would then transition from mindfulness outside of athletics into athletics, specifically focusing on details in the athlete's specific sport.

Goal-setting would also be of main focus in the final four weeks of the program. The basis of how to set goals and what are appropriate goals would be instructed before goal-setting was made an activity or goal of training. The goal-setting instruction, just as done with mindfulness, would be used in training first, then would be assigned to be worked on and documented outside of training (e.g., school or personal goals). Just like mindfulness or ACT, the homework, per se, would be reviewed at the next training. Both goal-setting and mindfulness would be programmed for generality.

This example of a potential program is provided at the end of this review in an attempt to set this new avenue of research for future behavior analysts that have a passion for both ABA and sports performance. It is important to note that though eight weeks would extend past what most studies have done, a program with flexibility would be most likely for success in understanding that all children (and adults) learn at a different rate, are able to acquire physical skills at a different rate and have different levels of cognitive ability and experiences allow mindfulness and goal-setting skills to be acquired at different rates. Not only should the timeline of training be flexible, but also the procedures used. All in all, this literature review provides hope for the future and for the many opportunities for new avenues of research.

Table 1. Articles reported that have met inclusion criteria identified

Authors (Year)	Sport	Participants	Experimental Design	Procedure	Target Behavior	Results	Follow up? If yes, what?
Harrison and Pyles (2013)	Football	3 male linebackers 16-17 years old High school	Multiple baseline across participants	Shaping and verbal instruction	Tackling	All participants had an increase in performance the intervention phases	No
Stokes, Luiselli, and Reed (2010)	Football	2 male linebackers 16- 17 years old High school	Multiple baseline across participants	Positive reinforcement	Tackling	Both participants had an increase in tackles executed correctly during the intervention and game phases.	No
Ward and Carnes (2002)	Football	5 male linebackers 19-21 years old Division II (NCAA)	Multiple baseline across behaviors	Goal Setting and Public Posting	Reads, Drops, and Tackles	Intervention successfully increased percentage of correct execution of all three target	No

						behaviors for all five participants	
Smith and Ward (2006)	Football	3 male wide receivers  Division II (NAIA)	ABACABC multitreatment withdrawal	Public posting plus verbal feedback and goal setting with verbal feedback and public posting with verbal feedback plus goal setting	Blocks, routes run, releases	All three interventions showed improvement in all three target behaviors for all three participants; most improvement with public posting plus verbal feedback plus goal setting	No
Tai and Miltenberger (2017)	Football	Six male defensive players  10-11 years old  Pee wee football league	Multiple baseline across participants	Behavioral skills training	Tackling-correct steps in a task analysis for tackling	Improvement was made in the intervention phase for all six participants	No

Bonner (2010)	Baseball	Two males 13 years old Middle school baseball	Multiple baseline across participants	Prompts (clicker training), modeling (videotaped form training), and reinforcement (verbal feedback)	Strike percentage and correct pitching form	Both participants had an increase in strike percentage and correct form in the treatment phase. In the follow up phase, the percentage of both strikes thrown and form decreased from treatment phase, but was still significantly higher than baseline percentages.	Yes; one week after end of treatment and during game settings,
Wolch, Arthur-Cameselle, Keeler and Suprak (2020)	Basketball	32 males Mean age: 21.22 Range from middle school	Multitreatment design with a control group and a mindfulness group	Mindfulness	Free throws made	During the high pressure phase, the mindfulness group made just under 10% more	No

level of  
basketball to  
junior college

free throws  
than the  
control  
group;  
however the  
ANCOVAs  
showed that  
mindfulness  
was not a  
statistically  
significant  
control factor

Rodrigues-  
Neto (2008)

Basketball

6 females

12-13 years  
old

Middle  
school

Multiple  
baseline  
across  
behaviors

Public  
posting and  
goal setting

Positioning  
on offense,  
positioning  
on defense,  
and  
positioning  
for rebound

All six  
players had  
an increase  
in correct  
positioning  
for all three  
behaviors  
during the  
intervention  
phase. Even  
after the  
fading phase  
and  
maintenance  
phase, the  
percentage of  
correct  
positioning  
remained  
higher than

Yes; during  
maintenance phase,  
data was collected  
during games

White (2017)	Basketball	Four females 14-15 years old High school	Multiple baseline across participants with a 3-day maintenance follow-up	Goal setting	Shooting and passing	baseline percentages All four participants had increased their percentage of made shots, but only two met their goals. For their passing goal, two participants met their goal in the follow-up phase, but not the intervention phase. Another participant did not meet their goal in either phase and the last participant was able to meet their goal.	Yes; 3-day maintenance phase
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Kladopoulos and McComas (2001)	Basketball	3 females 19-20 years old Women's NCAA Div II team	Multiple baseline across participants	Verbal instruction and positive social reinforcement	Percentage of shots made and percentage of shots taken with correct form	All three participants showed an increase in both percentage of shots made and correct form	No
Katarzi, Theodorakis, Tzetzis, and Vlachopoulos (2007)	Basketball	36 males Mean age: 29.3 years old Wheelchair basketball athletes who participated in the Greek National Wheelchair Basketball Championship	Multiple baseline across behaviors	Goal setting	Passing, shooting, and dribbling	Overall, the group that used goal setting scored higher than the group told to do their best, suggesting that goal setting can be effective in performance enhancement.	No
Mardon, Richards, and Martindale (2016)	Swimming	6 swimmers; 2 males, 4 female 18-22 years old	Multiple baseline across participants	Mindfulness	Performance time	Five participants had improved performance times, but one showed	No

		High Performance Program; competes nationally				a decrease in improvement . Three of the five had fairly significant increases in performance.	
Schonwetter, Miltenberger, and Oliver (2014)	Swimming	7 swimmers; 3 males and 4 females  Public High School Co-ed team	AB Design for three participants and an ABAC design for four participants	Self-monitoring, verbal feedback	Percentage of assigned laps completed	The three participants who were exposed to only the baseline and self-monitoring phases had an increased mean percentage of assigned laps. The other four participants in the self-monitoring with verbal feedback had an increase in the first intervention phase, a decrease in	No

						second baseline, and an even more significant increase in the second intervention phase.	
Gomberg (2014)	Golf	1 male 21 years old  College and has participated in amateur tournaments	Multiple baseline across behaviors	Mindfulness	Nine-hole scores, fairways hit, greens in regulation, approach shots within 15 feet of the hole, and putts per round	There was only a slight improvement in nine-hole scores, approaches, and putts. There was a slight decrease in performance in terms of green shots under two strokes and fairway shots.	No
Hoja and Jansen (2019)	Tennis	16 players; 7 male, 7 female, 2 undisclosed	Multiple baselines across participants	Mindfulness	Serve accuracy	Experimental group had just a slight increase in performance; control group	No

		Mean age: 26.50 years old				had slight decrease in performance	
		Tennis club					
Moore and Quintero (2019)	Weightlifting	Four participants; 2 males and 2 females  25-58 years old  Crossfit participants in an Olympic training program	Multiple baseline across participants	Forward and backward chaining	Clean and snatch	All participants had an increase in performance during the intervention phase; one participant had a decrease in performance with backward chaining, but then increased performance with the introduction of forward chaining	Yes; returned after a randomized number of training sessions for each participant.
Law and Ste- Marie (2005)	Figure skating	19 female skaters	Multiple baseline across participants	Self- modeling	Jumps	The experimental group had an overall	Yes; questionnaire given to the skaters

		Mean age: 13.4-14.2 years old				increase in jump performance in each intervention session. However, though slightly higher than the pretest performance, the retention phase saw a decrease in overall jump performance.	
		Intermediate skating club					
Anderson and Kirkpatrick (2002)	Speed Skating	4 skaters; one female and three male  12-16 years old  Competitive inline roller speed skating team	Multiple baseline across participants with a reversal design	Verbal Instruction and social positive reinforcemen t	Relay Tag	All skaters had an increased number of correct tags; results for skaters 1, 2 and 3 in the second treatment phase increased but had more variable results	No

Boyer, Miltenberger, Batsche, and Fogel (2009)	Gymnastics	Four female gymnasts 7-10 years old Gymnastics club	Multiple baseline across behaviors	Video Modeling and video feedback	Backward giant circle to handstand, a kip cast, and a clear hip circle	All four participants saw an increase in performance for all three behaviors during the intervention phase; however, some follow-up performances decreased from the intervention performance	Yes; weekly follow-up session without video modeling or feedback
Ste-Marie, Rymal, Vertes, and Martini (2011)	Gymnastics	22 females 9-16 years old Gymnastics club	Within-participants	Video modeling	Beam performance (execution and requirements met)	Two gymnasts dropped out involuntarily due to injuries sustained; overall, the gymnasts that used video modeling in intervention phase had	No

Barzouka, Bergeles, & Hatziharistos, (2007)	Volleyball	53 females  12-15 years old High school	Multitreatment with two experimental groups receiving feedback and one control group receiving only verbal instruction	Verbal instruction, expert modeling, video modeling, video feedback	Reception performance outcome and technique (included participants' ability to receive and return a free ball)	significantly greater mean scores All three groups had a significant increase in both performance outcome and technique. All three groups had a decrease in performance outcome retention, but had an increase in the technique during the retention phase	Yes; a retention phase was completed a week after the intervention phase for all three groups
Zetou et al. (2002)	Volleyball	116 children; 63 boys and 53 girls  12 years old  Elementary school	Multitreatment	Expert modeling, verbal instruction, self-modeling, video modeling	Set and serve results and form	There was a significant increase in both set and serve result and form for the expert modeling and self-modeling	Yes; a posttest 8-weeks following intervention/treatment and a retention test one week after the posttest

groups. The expert modeling group increased their scores in both the posttest and retention test for both result and form for both skills. The self-modeling group did have an increased score in the posttest, but only one (set form score) again increased in the retention test.

Table 2. Seven dimensions of applied behavior analysis in included articles

Author(s)/Year	Applied	Behavioral	Analytic	Conceptual Systems	Effective	Generality	Technological
Harrison and Pyles (2013)	Football	Tackling	Multiple baseline across participants	Shaping and verbal instruction	Yes	No follow-up conducted	No barriers present
Stokes, Luiselli, and Reed (2010)	Football	Tackling	Multiple baseline across participants	Positive Reinforcement	Yes	No follow-up conducted	No barriers present
Ward and Carnes (2002)	Football	Reads, drops, and tackles	Multiple baseline across behaviors	Goal setting and public posting	Yes	No follow-up conducted	No barriers present
Smith and Ward (2006)	Football	Blocks, routes run, and releases	Multitreatment withdrawal	Public posting plus verbal feedback and goal setting with verbal feedback and public posting with verbal feedback plus goal setting	Yes	No follow up conducted	No barriers present
Tai and Miltenberger (2017)	Football	Tackling	Multiple baseline across participants	Behavior Skills Training	Yes	No follow up conducted	No barriers present
Bonner (2010)	Baseball	Strike percentage and correct	Multiple baseline across participants	Prompts, modeling, reinforcement	Yes	Yes; one week after treatment and during game settings	No barriers present

Wolch, Arthur-Cameselle, Keeler, and Suprak (2020)	Basketball	pitching form Free throws made	Multitreatment	Mindfulness	Slight improvement, but not statistically significant	No follow up conducted	No barriers present
Rodrigues-Neto (2008)	Basketball	Positioning on offense, defense, and rebound	Multiple baseline across behaviors	Public posting and goal setting	Yes	Yes; maintenance phase conducted and data during games	No barriers present
White (2017)	Basketball	Shooting and passing	Multiple baseline across participants	Goal setting	All participants had increase in performance, but not all participants met goals set	Yes; 3-day maintenance phase	No barriers present
Kladopoulos and McComas (2001)	Basketball	Percentage of shots made and percentage of shots taken with correct form	Multiple baseline across participants	Verbal instruction and positive social reinforcement	All three participants showed an increase in both percentage of shots made and correct form	No	No barriers present
Katarzi, Theodorakis, Tzetzis, and Vlachopoulos (2007)	Basketball	Passing, shooting, dribbling	Multiple baseline across behaviors	Goal setting	Yes	No	No barriers present

Mardon, Richards, and Martindale (2016)	Swimming	Performance time	Multiple baseline across participants	Mindfulness	Five of six participants showed improvement	No	No barriers present
Schonwetter, Miltenberger, and Oliver (2014)	Swimming	Percentage of assigned laps completed	AB design for three participants and an ABAC design for four participants	Self-monitoring, verbal feedback	AB group had increased mean percentage. Of assigned laps; ABAC group had an increase in first intervention, significant decrease in second baseline, and an even more significant increase in second intervention phase	No	No barrier present
Gomberg (2014)	Golf	Nine hole scores, fairways hit, greens in regulation, approach shots within 15 feet of the hole, and	Multiple baseline across behaviors	Mindfulness	Slight improvement in three behaviors and slight decrease in performance in other three	No	Study designed and participated in by author, threat to validity

Hoja and Jansen (2019)	Tennis	putts per round. Serve accuracy	Multiple baseline across participants	Mindfulness	Slight increase in performance for experimental group, control group had decrease in performance	No	No barriers present
Moore and Quintero (2019)	Weightlifting	Clean and snatch	Multiple baseline across participants	Forward and backward chaining	All participants had increase in performance, one had decrease with backward chaining then showed improvement with forward chaining	Yes; returned after randomized number of training sessions for each participant	No barriers present
Law and Ste-Marie (2005)	Figure skating	Jumps	Multiple baseline across participants	Self-Modeling	Yes	Yes; questionnaire provided to skaters	No barriers present
Anderson and Kirkpatrick (2002)	Speed skating	Relay Tag	Multiple baseline across participants with a reversal design	Verbal instruction and social positive reinforcement	Yes; all skaters had an increased number of correct tags	No	No barriers present

Boyer, Miltenberger, Batsche, and Fogel (2009)	Gymnastics	Backward giant circle to handstands, a kip cast, and a clear hip circle	Multiple baseline across behaviors	Video modeling and video feedback	Yes	Yes; follow-up session without video modeling or feedback	No barriers present
Ste-Marie, Rymal, Vertes, and Martini (2011)	Gymnastics	Beam Performance	Within participants	Video modeling	Yes; outside of the two participants who dropped out due to injuries sustained	No follow-up conducted	No barriers present
Barzouka, Bergeles, and Hatziharistos (2007)	Volleyball	Reception performance outcome and technique (included participants' ability to receive and return a ball)	Multitreatment with two experimental groups receiving feedback and one control group receiving only verbal instruction	Verbal instruction, expert modeling, video modeling, video feedback	Yes; All three groups had a significant increase in both performance outcome and technique.	Yes; a retention phase was completed a week after the intervention phase for all three groups	No barriers present

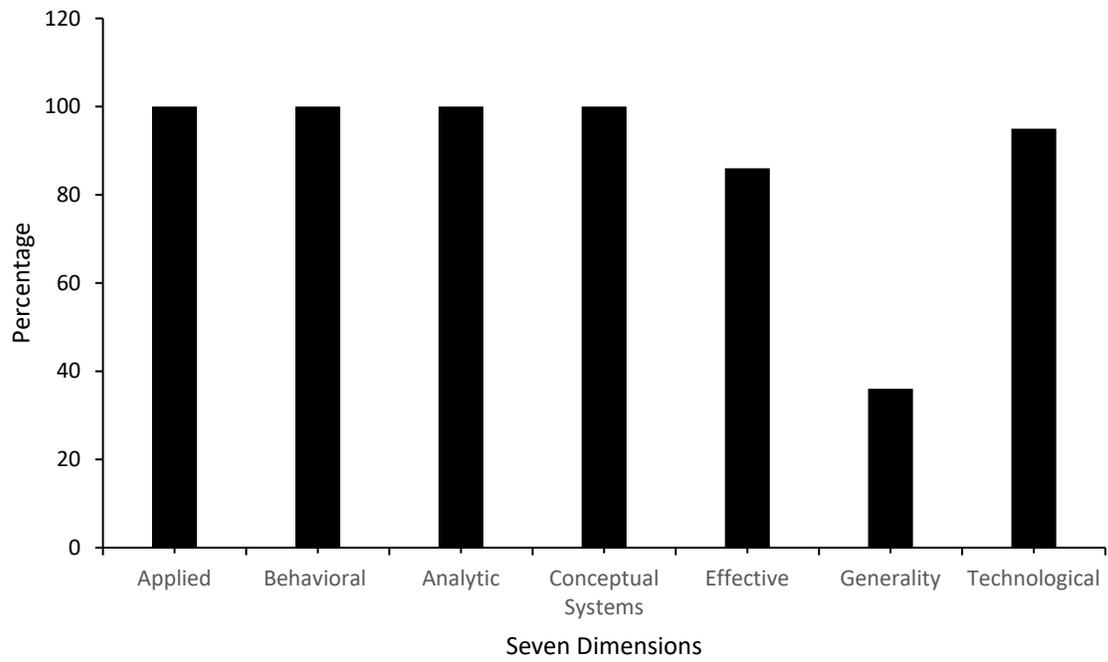


Figure 1. Analysis indicating number of articles out of the 22 included that met the criteria for each of the Seven Dimensions.