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Assessment and Improvement of Women's Soccer Performance using Precision Teaching and Frequency Building

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by

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Abstract

Assessment and Improvement of Women's Soccer Performance using Precision Teaching and Frequency Building

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Performance assessments may be a helpful tool to determine why performance is lacking in sports and fitness. They may also provide some examples of interventions that help improve performance. If the performance deficits are due to a lack of skill or knowledge, then one teaching procedure that may increase the performance of the skill is frequency building. The purpose of the present study was to use a sports performance assessment to identify the variables responsible for sub-standard performance on a college women's soccer team. In addition, we used a frequency building procedure to improve the performance of three soccer players. The results show that the assessment was useful to identify the reason for poor performance; all three players improved their identification of appropriate field positions. Two of three players also showed improved field positions during games.

Keywords: frequency building, performance analysis, soccer, sports

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Chapter 1: Introduction

Behavior analysis uses the principles of behavior to explain the behavior of individual organisms. Applied behavior analysis (ABA) is a subfield of behavior analysis in which the principles of behavior are applied to produce socially significant behavior change (Wilder et al., 2009). Along with ABA, other subfields of behavior analysis, including the experimental analysis of behavior (EAB) and the conceptual analysis of behavior, also exist. EAB focuses on expanding and defining the fundamental science of behavior while the conceptual analysis of behavior focuses on the philosophy behind the science. One subfield of ABA, organizational behavior management, or OBM, focuses on applying the principles of behavior to organizations to improve performance (Wilder et al., 2009). The goals of many sciences, including the science of behavior analysis, is to predict and control its subject matter (Hayes & Brownstein, 1986). So, ABA, EAB, and OBM all emphasize the prediction and control of behavior. ABA and OBM focus on producing behavior change that is significant to individuals and communities within a society, to create lasting behavior change. Both disciplines have grown and developed significantly since they began in the 1960s.

Although the application of ABA and OBM procedures have expanded to many different areas within society (e.g., schools, government, businesses, etc.), there are still gaps in establishing the best methods of producing lasting behavior change. ABA and OBM have also been used to produce significant behavior change in sports and fitness. Sports and fitness are relevant to society. For example, in a recent poll, 75% of adults in the United States report that they have played a sport when they were younger, 63% of people in the United States indicated that they were sports fans, and participation in sports provides social and health benefits (Schenk & Miltenberger, 2019). However, even though there is room for behavior analysis in sports, the most recent data on the Behavior Analyst Certification Board's (BACB) website has indicated that only .08% of certified behavior analysts identified health, sport, and fitness (HSF) as their primary area of professional emphasis (Holland & Slowiak, 2021, p. 2).

The first sports related behavioral research was conducted in the late 1960s and early 1970s and established that the methods of behavior analysis could be used in sports (Schenk & Miltenberger, 2019). Schenk and Miltenberger (2019) conducted a review of all the ABA and sports literature. The inclusion criteria for the review were as follows: there had to be a behavioral intervention that was used, and the target behavior had to be an observable behavior that measured sports performance (Schenk & Miltenberger, 2019). Schenk and Miltenberger (2019) found that 21 different sports had been assessed that met the inclusion criteria for their review. The sports included golf, swimming, American football, soccer, martial arts, gymnastics, and skating, among others. Overall, there were 101 articles that met the inclusion criteria. There were also 23 different procedures used in all of the studies reviewed that were organized into the following categories: consequence procedures (e.g., reinforcement, token reinforcement, auditory feedback, and chaining), antecedent procedures (e.g., instruction, goal setting, modeling, and prompting), feedback procedures (e.g., verbal, video, graphic, self-monitoring, and public posting), and skill training procedures (e.g., self-talk, self-imagery, rehearsal, simulated practice, and behavioral skills training (BST)) (Schenk & Miltenberger, 2019).

Overall, Schenk and Miltenberger (2019) explain that sports research has provided substantial contributions to behavior analysis and that multiple interventions have produced significant effects across many different sports behaviors. Schenk and Miltenberger (2019) did point out, however, that there is a lack of clarity when it comes to determining which component of these interventions caused the behavior change to occur, because a lot of the interventions used were delivered as a package, rather than being implemented individually. Some examples of packaged interventions were positive reinforcement combined with graphic feedback and modeling combined with video feedback (Schenk & Miltenberger, 2019). Although these packaged interventions may not be as informative as individual treatments, they were still effective, which is probably why they were used. However, Schenk and Miltenberger (2019) concluded that future research should assess which components are the most effective and identify how the various interventions can be used in different sports across age ranges. Because there were so many different interventions used, it is important for future research in

this area to establish which procedures are most effective in certain sports, at different ages, and across behaviors. One tool that may help facilitate the selection of certain procedures and interventions is performance assessments.

Performance Assessments in Sports

Behavioral or functional assessments are used in ABA to determine the environmental variables responsible for skill deficits and behavioral excesses. There are three different types of assessments used to identify the variables maintaining behavior in clinical work: indirect assessments, descriptive assessments, and experimental analyses. Indirect assessments aim to identify the maintaining function of behavior via interviews, and do not require direct observation. Descriptive assessments provide a more detailed account of behavior because these assessments require direct observation of the behavior in the natural environment. Experimental analyses are used to identify the variables maintaining behavior through experimental manipulation, observation, and analysis.

Behavioral assessments are also used in OBM to investigate, assess, and determine why substandard performance is occurring by an individual in an organization or group (Carr & Wilder, 2016). For example, the Performance Diagnostic Checklist (PDC) is the most common empirically supported assessment that is used to examine the performance of employees in organizations (Wilder et al., 2020). Performance analysis (PA) typically focuses on assessing the performance of individuals in an organization and is like a functional assessment that is used in clinical settings. The Performance Diagnostic-Human Services (PDC-HS) is a variation of the PDC that focuses on employees in human service settings specifically (Carr & Wilder, 2016). These assessments are used to help practitioners determine what variables may be maintaining substandard employee performance and can lead to effective interventions. The areas that the PDC-HS assesses are *training, task clarification and prompting, resources, materials, processes* and *performance consequences, effort*, and *competition*. The authors of the PDC-HS provided some sample interventions that can be used to address the hypothesized problem (Carr & Wilder, 2016).

Assessments are important in behavior analysis because they can provide information that

may identify why behavior is occurring. Behavioral assessments may also be a helpful tool that can be applied to the area of sports and fitness and may assist to determine why athletes may not be reaching the performance standards that are set by the coach.

Precision Teaching

Although Schenk and Miltenberger (2019) reviewed 23 different behavior analytic procedures used in sports, one procedure that was not evaluated was precision teaching (PT). PT came from laboratories and then to classrooms in 1965 (Lindsley, 1992). In the 1950s, Lindsley established the first human operant laboratory to experimentally analyze the behavior of people who were diagnosed with schizophrenia (Potts et al., 1993). While conducting his research, he verified that frequency of response was the most sensitive measure of all human behavior, and Lindsley developed the term "behavior therapy" (Potts et al., 1993). Lindsley went on to develop data-based classroom instruction for special education in public schools, and it is from there that PT was born (Potts et al., 1993). Lindsley (1992) expressed that PT should be used in school classrooms for all types of students because it enables teachers to create teaching techniques by monitoring daily frequency, using self-recording and the standard celeration chart (SCC; a logarithmic chart on which to display data) to display changes in the rate of learning. Lindsley (1992) pointed out, however, that PT is underutilized even though it had almost always doubled student's learning at essentially no cost.

Many behavior analysts have begun to implement PT into their practice, and it has become a basic competency for Board Certified Behavior Analysts (Evans et al., 2021). Evans et al. (2021) conducted a literature search of the history of PT and an updated summary of PT. These researchers decided to create a more synthesized definition of PT and searched through the PT literature to develop a list of critical features, since PT has been used in a variety of different ways. Evans et al. (2021) defined PT as "a system for precisely defining and continuously measuring dimensional features of behavior and analyzing behavioral data on the SCC to make timely and effective data-based decisions to accelerate behavioral repertoires".

Although there are many different features of PT, the critical features are those that must be

present for the procedure to be called PT. Evans et al. (2021) explained that PT is not a teaching procedure but a way to measure learning and make decisions about teaching based on the data that are recorded on the SCC. The following are listed as the critical features of PT: accelerating behavioral repertoires, precise behavior definitions, continuous observation, dimensional measurement, use of the SCC, and timely and effective data-based decisions. The outcome after implementing PT is typically faster skill acquisition and accelerated behavioral repertoires. However, PT is a process that focuses on the measurement of the learning that occurs and the patterns in the data obtained and is not itself a teaching procedure. PT also includes "pinpoints" or definitions of behavior that are observable and measurable in an objective and precise way. Continuous observation is also fundamental to PT because every instance of the behavior is important to measure and analyze quickly. The most common form of measurement that is used in PT is rate, or the number of instances of behavior (frequency) over some unit of time, but other measurements of behavior are also used, such as latency and duration. PT depends on some way of measuring and using a visual display to show the gains and losses of a certain behavioral repertoire. The SCC has become widely used in PT and offers a standardized visual display of behavior and its relationship to the procedures implemented. Finally, the SCC is used to facilitate decision making on the effectiveness of a procedure. Practitioners observe the chart often, usually daily, through visual inspection to analyze the data recorded and decide whether a change needs to be made (Evans et al., 2021).

When PT was first developed, it was primarily used in classroom settings to increase arithmetic or reading repertoires. Schirmer et al. (2007) implemented precision teaching to teach a 3-year-old boy with autism how to engage in storytelling. In the first practice phase, the experimenters described a scenario, and the participant was required to tell a story that included the information that was given. Some examples included a girl at a baseball game, a boy on a farm, and a dog getting a bath. The participant's score in the first phase of timed practice began at 21 correct syllables per minute and reached 90 per minute within the first five days of precision teaching practice sessions. The second phase allowed the participant to create any story he wanted, and in this phase the

participant's frequency score increased to 150 syllables per minute. In each phase, the participant was shown his progress on the SCC and was given certain goals to meet based on previous performance. To check for stability, the participant was required to complete a timing in a different setting and with a distraction of a television in the background. After the participant matched his previous performance under those conditions, the experimenters tested for endurance by increasing the timing from one minute to three minutes. The participant matched his previous performance under those conditions as well. Overall, precision teaching was a successful tool in developing story telling behavior in a young boy with autism (Schirmer et al., 2007).

Although PT has been used to teach academic skills, it has also been applied to many other areas including self-management, motor skills and sports and fitness performance (Evans et al., 2021). However, these are limited to only a handful of studies (Pallares et al., 2020). One study conducted by McDowell et al. (2002) used video modeling and PT to improve two skills required for swinging a golf club. One right-handed amateur golfer participated in the study and two skills (grip and posture) were pinpointed and precisely defined for measurement. Before the procedure began, the experimenters analyzed an instructional video and defined grip and posture. Grip was precisely defined as holding the club with the forefinger and thumb with only the first and second knuckles of the left hand showing, while the right hand was placed on the club which rested on the second joint of the right forefinger (McDowell et al., 2002). Posture was precisely defined as the feet and legs had to be the correct length apart, the club was positioned close to the right leg, with the right arm straight and the left arm bent at the elbow, and the position of the head and shoulders had to be correct (McDowell et al., 2002).

During baseline, the timer began when the learner was asked to grip the club, and the timer was stopped after the learner said "okay". The grip was then examined and scored, and the experimenters continued this procedure for one minute. Posture was observed using the same procedures, and no instruction, prompts, or feedback were given during baseline. Intervention consisted of teaching sessions in which the learner continuously practiced gripping the club and was

given feedback as to which criteria was correct or incorrect. The same procedures were used for posture. After the teaching sessions, the experimenters conducted 30-second timings, the learner was told to complete as many timings for each skill as he wanted, and the SCC was used to chart the participant's progress. Overall, in baseline the participant gripped the club correctly six times and incorrectly twice. After the intervention was implemented, in the first timing, the participant gripped the club correctly ten times, and incorrectly zero times. The participant reached the aims set by the experimenters in the fourth session. During a maintenance check four weeks later, the participant gripped the club correctly 30 times and incorrectly twice. During baseline, the participant engaged in the correct posture seven times and the incorrect posture three times. After the intervention in the first timing, the participant scored eight correct posture positions and four incorrect posture positions. The participant reached the aims set by the experimenter in the third session. During the maintenance check for posture, the participant scored 34 correct and two incorrect. McDowell et al. (2002) explain that their results suggest that their teaching intervention (identifying components, repeated practice, instruction, and feedback) was successful in improving the fluency for engaging in the correct form of grip and posture.

Another study examined the use of PT procedures to improve tap dancing steps in four novice dancers (Pallares et al., 2020). Experienced dancers established the performance criteria for the dance step pairs that were used in the study (e.g., toe taps, heel taps, dig steps, etc.). Individual sessions were conducted for 10-15 minutes four times per week with each participant. Baseline consisted of three 15-second timings for each step, and the participants did not receive any feedback. After baseline, certain steps were chosen for training and the procedure for frequency building began. The frequency building sessions consisted of three 15-second timings for the steps they were targeting for training. Before each timing the instructor provided goals (based on previous performance shown on the SCC). If the participant reached the goal, the instructor provided praise and feedback. If the participant did not reach the goal, the instructor provided corrective feedback. If the participant failed to meet the goals for the entire session, the instructor implemented other interventions like prompting or revising

the goal. Overall, each participant had accelerations and decelerations of different dance steps, for example three participants had accelerations during the weekly probes for tip steps and dig steps, with one participant having a significant deceleration in errors for dig steps. The researchers also conducted retention probes, which consisted of testing the steps after they had reached mastery and found that all four participants demonstrated retention across many of the steps that were trained. Endurance probes, which consisted of 30-second timings, were also conducted, and demonstrated that all four participants had shown improvements in that area. Overall, Pallares et al. (2020) conclude that applying PT to construct and monitor different forms and rates of performance in sports can be successful. Along with that, Pallares et al. (2020) explain the importance of fluency instruction, in that high rates of fluency of one complex skill can facilitate the acquisition of more complex skills. For example, a basketball player who can dribble the ball accurately and quickly may also learn to pass and shoot the ball quicker and more accurately as well.

Fluency is key when it comes to PT. Fluency is important in school settings because it is one way to show and measure expertise (Chiesa & Robertson, 2000). In PT, the time probes provide a snapshot of fluency based on the rate (some frequency over time) of a certain behavior (Chiesa & Robertson, 2000). The timings can be short, as they typically are in PT (15 seconds, 30 seconds, etc.), but if the rate of performance is increasing, it can still be a measure of becoming more fluent in a skill. Throughout the process of PT, research has shown that building responses to higher rates of responding does lead to behavioral fluency (Pallares et al., 2020). Fluency is not only important in education but is also an important skill when trying to be an expert in any area. Fluency is especially helpful in sports; a soccer player who can quickly and accurately scan the field for an open field position as their team is making their way up the field will perform better than a player who takes ten seconds longer to engage in the same behavior.

Frequency building is one procedure that is used in PT to specifically build and create fluent repertoires. It is a procedure that involves the timed repetition of a behavior followed by performance feedback, which can lead to behavior that may seem automatic or masterful (Pallares et al., 2020).

Lokke et al. (2008) used PT and frequency building to teach fluency in a basic ballet move. The participant in the study was a 9-year-old girl who had 5 years of experience dancing (Lokke et al., 2008). The dependent variable was a specific dance move that involved many different moves (i.e., short jumps on left foot, making a 30 degree turn, keeping the knee bent, right foot pointed and tapping the floor lightly), and the timings for all sessions consisted of 15 seconds. The frequency of the correct and incorrect scores were charted using the SCC after each session. Before the timed sessions, the participant was provided with a detailed description of the behavior and was instructed to accurately complete as many moves as she could. After the timings, praise was given for correct movements, and corrective feedback was given for incorrect movements. The participant trained for a total of 180 minutes over the course of 9 days (20 minutes per day). Overall, the frequency building procedure seemed to be effective in teaching fluency for one ballet move. During baseline, the rate of correct responding was 80 jumps in one minute, and 4 incorrect. During the learning sessions, the rate of correct responding increased to 188 jumps in one minute with zero incorrect. Lokke et al. (2008) emphasize that their experiment used only an AB design, so the results may not have been a direct result of the frequency building procedure, and that more research in sports should be done using PT and frequency building.

Although frequency building procedures have rarely been used in sports, they have been used in academic settings for decades. Kostewicz et al. (2019) implemented frequency building to increase spelling repertoires in three kindergarten children; the dependent variables in the study were the frequency of letters spoken correctly and incorrectly during a daily spelling assessment. Students engaged in three different practice types (i.e., see letter say sound, hear letter say letter, and hear word say sound) during the intervention portion of the study (Kostewicz et al., 2019). Baseline sessions consisted of a daily spelling assessment, after the assessment there was no feedback or error correction provided; during the intervention sessions the participants completed the spelling assessment and then engaged in a frequency building practice sequence (i.e., see letter say sound, hear letter say letter, and hear word say sound). The students had to reach a certain criterion before moving onto the next

sequence during the teaching sessions. Overall, all three participants increased the number of spelling words correct with the scores being: 5, 15, and 10 correct in baseline and 28, 25, 23 incorrect in baseline. After implementing the frequency building intervention in the final session, the participants scored 20, 30, and 18 correct and 9, 21, and 19 incorrect (Kostewicz et al., 2019).

Performance assessments are tools that behavior analysts use to identify the variables responsible for problematic performance. PT is a procedure that can be utilized when a lack of skill is determined to be a potential cause of poor performance. Frequency building can be a useful procedure when trying to increase fluency in any behavior, especially in sports. To date, no research has combined these two procedures to assess and improve sports performance. Therefore, the purpose of this study was to use a modified PDC to identify the variables responsible for poor performance on a college women's soccer team. Based on PDS results, we evaluated a PT and frequency building procedure to increase fluency of an athletic skill.

Chapter 2: Method

Participants

The participants for this study were three players on a National Collegiate Athletic Association (NCAA) Division II Women's soccer team at a private university in east central Florida. All three participants were females, aged 19-21. All three participants played in the midfield (two defensive midfield and one attacking midfield) and had been playing soccer since they were 4 years old. In order to participate in this study, they had to have played in at least 5 games from their previous season, and had to have a score of less than 90% for on-field positioning in the games from their previous season.

Setting and Materials

The study was conducted at a private university in east central Florida. Phase 1 of the study was conducted in the coach's office, which is on campus at the university. The materials used for the study were the modified PDC, a white board, 22 magnets, field position scenarios, a pen, and a standard celeration chart for each participant. Data for phase 2 of the study were collected via video records of soccer games (these videos had already been recorded by the team pior to the start of this study).

Procedure

First, the researcher conducted interviews from the modified PDC (PDC-Sports; see Appendix A) to identify areas for performance improvement amongst the players. The PDC-Sports was adapted from the PDC-HS (Carr & Wilder, 2016) and tailored to sports performance rather than employee performance. The sections included in the PDC-Sports were (a) *Training*, (b) *Task Clarification and Prompting*, (c) *Materials, Resources, and Processes* and (d) *Performance Consequences, Effort, and Competition*. The PDC-Sports was used to evaluate the extent to which the tool is useful to identify a performance deficit. The researcher interviewed the coach about areas for improvement. After the assessment, the area that was targeted for improvement was the behavior of describing appropriate

field positioning given a scenario. This behavior was first tested under baseline conditions, and then each participant went through a frequency building practice procedure. Finally, in phase 2, participant performance on the field in actual games was evaluated, both before and after participants were exposed to the intervention. Momentary time sampling using 10 s intervals was used to measure field position.

Dependent Variable

During phase 1, the dependent variable was the rate of correct responses of field position in a one-minute timing. The test probes were conducted one day per week to measure the rate of responses. The data were graphed on the SCC by the participant. During phase 2, the dependent variable was the average percentage correct of appropriate field position in a game setting. Baseline data were collected by measuring the percentage correct of appropriate field position from video recordings of games that were played six months prior to the start of this study. After exposure to frequency building, videos of games were again reviewed. Percentage correct of appropriate field position was measured by using momentary time sampling of 10-s bins. If the participant was in the correct position at the end of the 10-s interval, she was scored correct for that bin. The total number of bins correct was divided by the total number of bins and converted into a percentage.

Interobserver Agreement (IOA) data were collected by a second, independent observer. To calculate IOA in Phase 1, the total number of correct responses per timing obtained by observer 1 was compared to the total number of correct responses obtained by observer 2. The smaller number was divided by the larger number and converted to a percentage. The average agreement in phase 1 was 96% with a range of 90-98. To calculate IOA in phase 2, the number of 10 second intervals with agreement was divided by the total number of 10 second intervals and converted to a percentage. The average agreement in phase 2 was 88% with a range of 80-95.

Independent Variable

During phase 1, the independent variable was a frequency building procedure of practicing indicating correct field position based on various scenarios. This procedure involved practicing

indicating appropriate field positioning on a white board with magnets depicting the location of other players. The participant had to put their magnet on the white board indicating that is where they should be on the field given that scenario. Each session consisted of teaching four scenarios, and then the participant was tested using the testing packet.

After the frequency building procedure was implemented, on field performance was also measured in phase 2. Baseline data were measured by observing video footage of games three to six months prior to the beginning of the study. The percentage correct of appropriate field positioning was measured from the video footage. After phase 1, games that each participant competed in were also recorded and data were collected to measure percentage correct of appropriate field positioning to compare to baseline data. If percentage correct of on-field positioning was improved, there was no need for further intervention. However, if percentage correct of on-field positioning did not improve, a feedback intervention was implemented to improve on field performance (although this was never necessary).

Data on independent variable integrity were also collected. In phase 1, an independent observer recorded whether each participant was given the white board with magnets representing field position and was given a one-minute timing. In phase 2, an independent observer would have measured the content and timing of feedback delivery if feedback was delivered to participants (it was not necessary).

Procedure: Phase 1

Baseline

During baseline, the participant was asked to complete a packet with different field position scenarios as fast and as accurately as possible in a one-minute timing. The packet was filled with 50 different field position scenarios that the coach helped the researcher create. The scenarios were given to participants in random order. The packet consisted of different field position scenarios and the participant was instructed to put an X to indicate where she should be on the field. No feedback or error correction was given during baseline.

Frequency Building Practice

The frequency building practice procedure consisted of the following: the participant was given a white board that had a soccer field outlined on it with magnets that represented the players on a field. She was asked to indicate where the missing magnet should go with an X; the participant was told to take her time and perform as accurately as possible. After a correct response, the participant was given verbal praise from the coach; after an incorrect response the participant was provided with error correction by the coach immediately after the response. There were four practice scenarios, and then the participant was given the testing packet and was asked to complete as many field position scenarios as fast and as accurately as possible in a one-minute timing. After the timing, the coach scored the packet and the participant filled out the number of correct and the number of incorrect responses on the SCC. The experimenter conducted timings after the practice sessions and set aims after each session for each participant. There was a total of at least three practice sessions, however, if the participant needed more practice to reach the mastery criteria, more frequency building sessions were conducted. Lindsey participated in a total of 19 sessions, Forlan participated in 23 sessions, and Victor participated in 24 sessions before reaching their mastery criteria. Each participant had different aims to reach based on their baseline score. For example, if one participant scored five correct in baseline, the aim for their first sessions was set for seven. If a participant did not reach the aim in a session, the aim was reevaluated and changed to a more attainable aim. The aim or mastery criteria was a doubling in performance from baseline to the intervention. Lindsey's aim was set to 6.8 correct, Forlan's aim was set to 2 correct, Victor's aim was set to 9.1 correct.

Experimental Design

A concurrent multiple baseline across participants design was used in Phase 1. One participant began the frequency building procedure while the two others continued in baseline, then the frequency building procedure was delivered in a staggered manner to demonstrate experimental control.

Procedure: Phase 2

Baseline

During baseline in Phase 2, data on percentage correct of appropriate field positioning was measured and recorded from video footage of games in which each participant played three to six months prior to the beginning of the current study. Momentary time sampling was the data collection method used with 10-second bins of 15-minute game segments.

Intervention

The researcher evaluated the total percentage correct of appropriate field positioning by measuring performance on the field during the first games in which the participant played after the completion of phase 1. If appropriate field position was at 90% or higher, the researcher continued to evaluate more games, and did not provide any additional intervention. However, if the participant's percentage correct of appropriate field positioning did not reach 90% or greater after phase 1 alone, then the researcher implemented a feedback procedure.

The feedback procedure (had it been implemented) would have consisted of the coach reviewing game footage with the participant. The coach would have provided corrective feedback for instances in which the participant was not in the appropriate field positioning, and positive feedback when the participant was in the correct field positioning. Feedback would have been implemented within 48 hours after each game and would have lasted no longer than 20 minutes.

Experimental Design

A multiple baseline across participants design was used in Phase 2. One participant received the feedback while the others remained in baseline. The feedback was implemented in a staggered manner across participants.

A social validity survey was also administered to participants. The survey asked if participants approved of the intervention and the outcome. Questions were answered on a 5-point Likert scale (see Appendix B).

Chapter 3: Results

Prior to the beginning of the study, the PDC-Sports was used to evaluate the potential cause for performance deficits among the three participants. The experimenter interviewed the coach using the PDC-Sports. Figure 1 depicts the scores for all three participants across all the domains evaluated from the PDC-Sports. For all three participants, the percentage of questions answered no was 75% in the Training domain, 0% in the Resources, Materials, and Processes domain, 0% in the Task Clarification and Prompting domain, and 40% in the Performance Consequences, Effort, and Competition domain. The domain on which all three participants scored the highest (indicating the greatest performance deficit) was training. The participants also received a higher score on the performance consequence, effort, and competition domain, but that was because the skill is not simple or low in response effort and there are other competing skills during a soccer game. However, those components of the skill could not be altered, so a precision teaching procedure was implemented to attempt to improve the training issue. The consequences domain was not addressed.

Phase 1 Results

Figure 2 depicts the rate of correct and incorrect responses performed by all participants throughout baseline and the intervention phases. All participants increased their frequency of correct responses while decreasing the number of errors. During baseline, the average rate of correct responses for Lindsey was 3.4 per minute and the average rate of incorrect responses per minute was 4.8. After the frequency building procedure was implemented, Lindsey's average rate of correct responses per minute increased to 5.9 while her average rate of incorrect responses per minute decreased to 2.

During baseline, the average rate of correct responses for Forlan was 1 per minute and her average rate of incorrect responses per minute was 3. After the frequency building procedure was implemented, Forlan's average rate of correct responses per minute increased to 4.1 while her average rate of incorrect responses per minute decreased to 0.9.

During baseline, the average rate of correct of responses for Victor was 4.7 per minute and her average rate of incorrect responses per minute was 5.9. After the frequency building procedure was implemented, Victor's average rate of correct responses per minute increased to 10.2 while her average rate of incorrect responses per minute decreased to 2.1.

Phase 2 Results

Figure 3 depicts the percentage correct of appropriate field positioning across games that were played prior to the beginning of the study and games that were played after the implementation of the frequency building procedure. Lindsey had an average of 80% appropriate field positioning in baseline and 92.6% appropriate field positioning after the implementation of the frequency building procedure. Forlan had an average of 85.1% in baseline and had an average of 95.3% appropriate field positioning after the implementation of the frequency building procedure. While Victor was participating in the study, she had an injury that prevented her from playing in any games after the frequency building procedure was implemented, so game data were not collected for her. Since 90% appropriate field positioning was achieved immediately upon introduction of the intervention, no feedback was provided to participants.

Social Validity

A social validity questionnaire was administered with all three participants. The questionnaire consisted of a survey with a Likert scale of 1-5 with a score of 1 being strongly disagree, and a score of 5 being strongly agree. The results from the social validity questionnaire suggest that all three participants believed the teaching procedure was effective for learning field positioning (one participant rated a 4, and two rated a 5) and enjoyable (all three participants rated a 5). All three participants also indicated (i.e., rated a 5) that they enjoyed receiving feedback from their coach and that they enjoyed seeing their progress visually on the SCC. All three participants also said that if they had the opportunity to participate in the teaching procedure again, they would do so.

Chapter 4: Discussion

The purpose of this study was to evaluate the use of an assessment tool (the PDC-Sports) to examine performance deficits on a sports team, and to use the results to evaluate a frequency building procedure to improve player performance. The PDC-Sports suggested that a training issue was responsible for poor performance. We then examined if a precision teaching procedure, specifically frequency building, could improve the skill of appropriate field positioning on a collegiate women's soccer team. All three participants showed improvements in the fluency of indicating appropriate field position, and both participants who were able to play in games after the implementation of the teaching procedure showed improvements in field positioning in an actual game setting.

On-field positioning is important for college soccer players; if each player is organized and can move around the field efficiently and effectively, it can be very difficult for teams to break through the lines of the players and get to the goal. This study focused on improving this specific skill because at the college level, complex behaviors like the one measured in this study are necessary. A soccer player has only a few seconds to decide where they are going to go next on the field, so improving the fluency of this skill is important. The results from the current study indicate that after implementing a relatively simple frequency building procedure, soccer performance can improve.

Behavior analytic research in sports and fitness has yielded a number of assessment and intervention techniques, but there are still gaps in the literature when it comes to identifying which components of these interventions are the most effective across sports, age ranges, and performances (Shenck & Miltenberger, 2011). Shenck and Miltenberger (2011) conducted a review of all the behavior analytic applications in sports and identified many effective procedures but noted that selecting interventions to use may be difficult for some practitioners because most interventions have been evaluated in packages. Although often effective, it can be difficult to identify the specific components of package interventions that contribute most to the behavior change that is observed. One way to mitigate this issue is to use an assessment tool to help identify performance issues across

sports, ages, and behaviors. The assessment tool can then be used to help facilitate the selection of the procedures that researchers and practitioners can utilize.

The field of behavior analysis places emphasis on the use of assessment to identify potential causes of behavior performance. Assessment makes possible the identification of the variables responsible for performance. Although there is a long history of the use of assessment tools in ABA, such as the functional analysis in clinical settings and the PDC and PDC-HS in organizational settings, no such tool has been created specifically for the area of sports and fitness (Hanley et al., 2003, Wilder et al., 2020). That is why we examined the development of a modified PDC to evaluate the potential causes of performance issues among college women soccer players in the current study. The PDC-Sports was adapted from the PDC, and included the following domains: *Training, Materials and Resources, Task Clarification and Prompting,* and *Performance Consequences, Effort, and Competition* (Wilder et al., 2020*).* Although this study is the first to evaluate the PDC-Sports, the validation of the tool is incomplete. That is, because we only evaluated one domain (Training), future studies will need to examine other PDC-Sports domains before the tool can be considered adequate to serve its purpose.

This study also extends the PT literature. In the past, PT has been used mainly in school settings when teaching fluency of educational skills such as reading and math. However, PT has also been used in many other areas including motor skills, self-management, and sports and fitness performance (Evans et al., 2021). Evans et al. (2021) conducted a literature review of PT to develop a list of its critical features. According to these researchers, these critical features of PT must be present for a procedure to be called PT. The following components were identified as the critical features of PT: accelerating behavioral repertoires, precise behavior definitions, continuous observation, dimensional measurement, use of the SCC, and timely and effective data-based decision making.

Although PT has been used in a variety of ways, there are only a few studies that have used precision teaching to teach a sports related behavior. McDowell et al. (2002) implemented an intervention that utilized PT and video modeling to improve the golf swing in one amateur golfer. The

dependent variables measured in the study were appropriate grip and posture. The researchers explain that their teaching procedure, which consisted of repeated practice, instruction, and feedback, did improve the participant's posture and grip. The teaching procedure used in this study was like the frequency building procedure used in the current study, and incorporated some of the same elements, such as repeated practice and performance feedback.

Pallares et al. (2020) also examined the use of a PT procedure to improve tap dancing steps in novice dancers. They used frequency building, which consisted of the timed repetition of a behavior followed by performance feedback. All four participants in the study showed improvements for the steps that were targeted for teaching. Pallares et al. (2020) also emphasized that a main feature of PT is that it promotes fluency in responding. Fluency is an important feature for mastering many different skills, including academic skills, such as math and reading, but it is also an important feature for many athletes. When a person becomes fluent in a skill, it means that they can perform the skill accurately and quickly, so the duration of the response time decreases. This is important not only in academic skills among students, but also for athletic skills among athletes. Athletes who can respond more quickly in certain situations will perform better than athletes who do not respond as quickly. Building fluency in one skill can also facilitate the acquisition of fluency in other skills (Pallares et al., 2020). The current study is like the one conducted by Pallares et al. (2020) in that the frequency building procedure facilitated an increase in the fluency of an athletic skill.

This study extends the use of PT within the area of sports and fitness performance and contributes to the findings of similar studies that the use of PT can be effective in teaching fluency in an athletic skill. The athletic behavior that was selected to teach in this study is also different than other behaviors observed in previous studies. The behavior of identifying appropriate field positioning is more complex; it takes many soccer players years to really learn this skill. That is why this specific behavior was chosen for the population in this study. Prior to this study, most of the behavior analytic sports research has been conducted with populations who were novel to the sport or the activity. It is important for research in this area to begin to identify the best procedures to use with different sports,

different experience levels, and across different behaviors.

The teaching procedure used in this study was also easy to implement, inexpensive and did not take much time. PT is unique in that it is a teaching procedure that allows for quick data-based decision making if a learner is not improving the fluency of a skill. One participant in this study, Lindsey, was not reaching the aims set by the experimenter, so the experimenter identified that the presentation of the soccer field on the white board may have been affecting her responses, since the soccer field on the white board and the soccer field on the testing packet had slightly different dimensions. In session 14, we decided to present the scenario with the same dimensions as the testing packet and did not present scenarios using the white board. After changing the modality of the scenarios presented during the teaching procedure, Lindsey immediately improved her rate of correct responses and we saw a decrease in the rate of incorrect responses. This trend continued until Lindsey met mastery criteria.

Another key feature of PT that all the participants in this study reported that they enjoyed was the use of the SCC. In this study, the SCC was used similar to how a timings chart would be used; multiple data points werer collected in one day, so the experimenter used the vertical lines to represent individual timings rather than individual days. The SCC is a unique feature of precision teaching. The SCC provides a way for the learner to visually see their own progress of the target skill. The SCC is a tool that can provide immediate graphic feedback to the learner and allow the experimenter to make data-based decisions very quickly. Although the SCC may take some time to learn how to use, all three participants learned how to use it in one session and reported that they looked forward to seeing their progress on the chart.

Limitations

This study has a few limitations. The first limitation is that the dependent variables that were measured in this experiment are somewhat subjective. There are many factors that may determine what is and what is not the correct field position. Some of these include the ball position, the time of the game, the current score of the game, and the formation in which the team is playing. Every coach

may also have a different idea of correct field positioning for a certain player at any given moment. However, although the dependent variables in this study were somewhat subjective, the coach is the ultimate decision maker regarding whether their player is in the correct position or not. That is why it was crucial for the coach to be involved with the implementation of the independent variable. Second, the definition of correct responses could have been more precise. For example, in phase 1, the coach scored the packet to determine what a correct response would be, but there was some variability in the position of the X from time to time (it was not always on the exact same spot on the page, but within an inch of the correct spot). Third, one of the participants, Victor, was injured while participating in the study, and so we were unable to collect game data to evaluate if the effects of the frequency building teaching procedure generalized to an actual game setting. Fourth, we collected no maintenance data for any of the dependent variables measured to determine if the fluency of indicating the appropriate position maintained across time. Maintenance data were not collected because this study was conducted in a spring semester for a thesis project and had to be submitted before the participants returned from their summer break. Fifth, there was a large gap of time between the baseline data collected in phase 2 and the data collected after the intervention took place. This gap of time could have impacted the participant's scores and could affect the validity of this study. There also should have been more baseline data collected for participant one during phase 2. The trend during baseline is going up, and the researchers should have collected another data point to indicate that the behavior that was being measured was not improving. Finally, our second dependent variable, field positioning during games was high in baseline. Thus, a ceiling effect may have occurred in that participants could not improve much beyond baseline.

Future Directions

Future research should investigate the use of the PDC-Sports and evaluate the other PDC-Sports domains with athletes. Future studies should also investigate the use of precision teaching as a procedure for teaching athletic and sports skills at varying ability levels and across different sports. Along with the use of precision teaching, frequency building, and other teaching procedures should be

used to teach different sport behaviors. Building fluency in a skill is important when establishing a new skill, and it is important for maintaining the skill across time. There should also be future replications of this study to demonstrate its effectiveness and consistency. Future replications of this study should improve on these limitations by including more precise definitions, collecting game data from more recent games, and recording specific 15-minute segments in games such as only recording the first 15-minute segment of each game.

Conclusions

This study is the first to demonstrate the use of a tool (PDC-Sports) to evaluate sports and fitness performance among college athletes. Behavior analysts place emphasis on the importance of evaluating potential causes for performance issues among all areas of practice, so the use of such a tool in sports and fitness may be helpful to identify why performance issues are occurring.

This study is also the first to analyze the use of PT, specifically a frequency building procedure, to teach a complex skill among advanced soccer players. Previously, most behavior analytic research in sports and fitness has focused on teaching skills to novice athletes. It is important for researchers to also evaluate more complex skills to attempt to improve even expert level athletic skills.

Although there are limitations to this study, the participants did improve their ability to indicate the appropriate field positioning given a scenario. Two participants also showed improvements on the field and demonstrated an increase in appropriate field positioning in an actual game setting. The participants also reported that they enjoyed the teaching procedure, and they believe that it will help them in the future when they are playing in a soccer game. One participant even reported to the experimenter that while she was playing in a game, she was thinking back to the teaching procedure, and it helped her in that situation. This study provides more behavior analytic research in sports and fitness and extends previous literature that demonstrated that a precision teaching procedure can be effective at teaching athletic behaviors.

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Figure 1

Scores from the various PDC-Sports domains Lindsey, Forlan, and Victor.

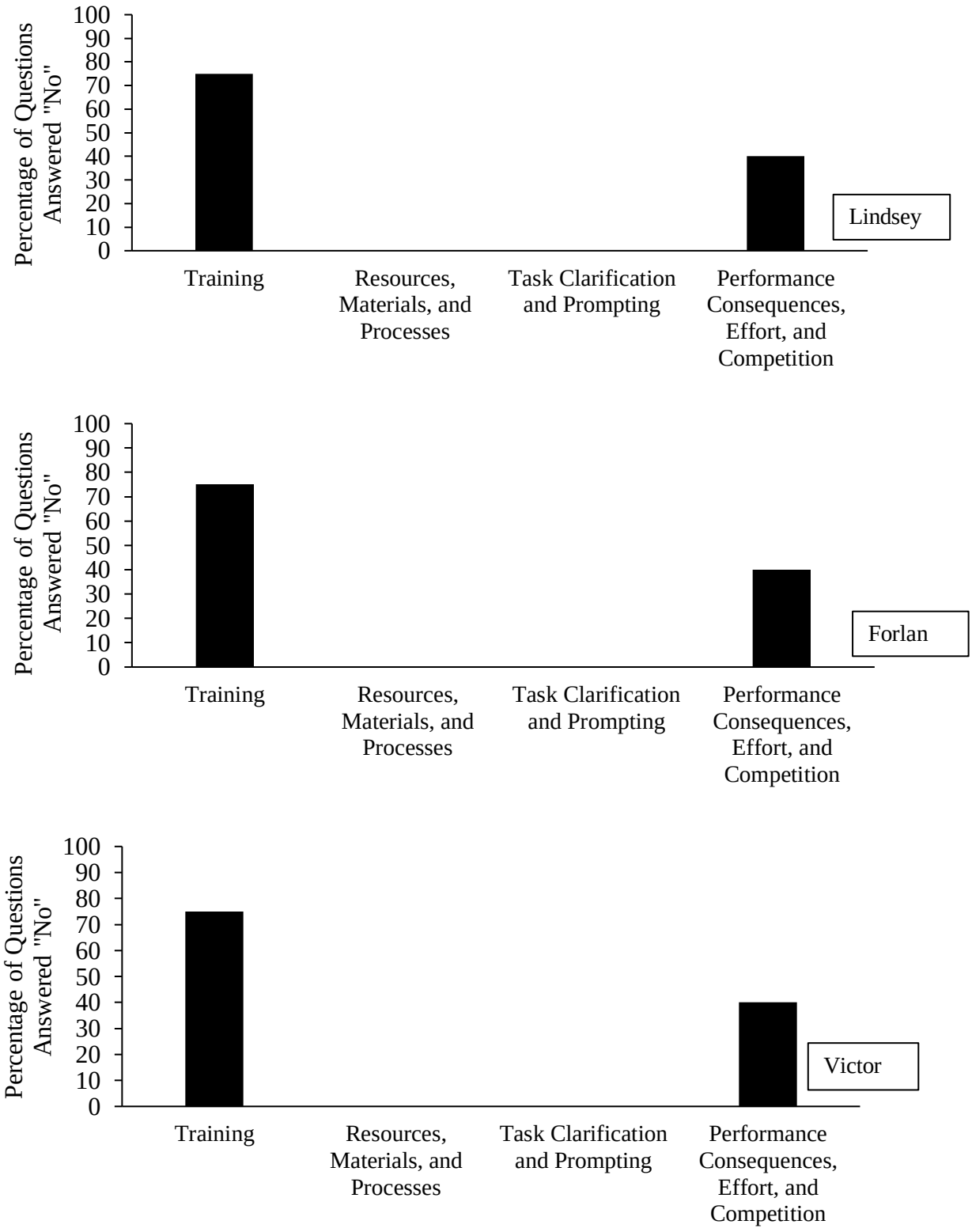


Figure 2

Rate of responses during baseline and frequency building procedures (phase 1) for Lindsey, Forlan, and Victor.

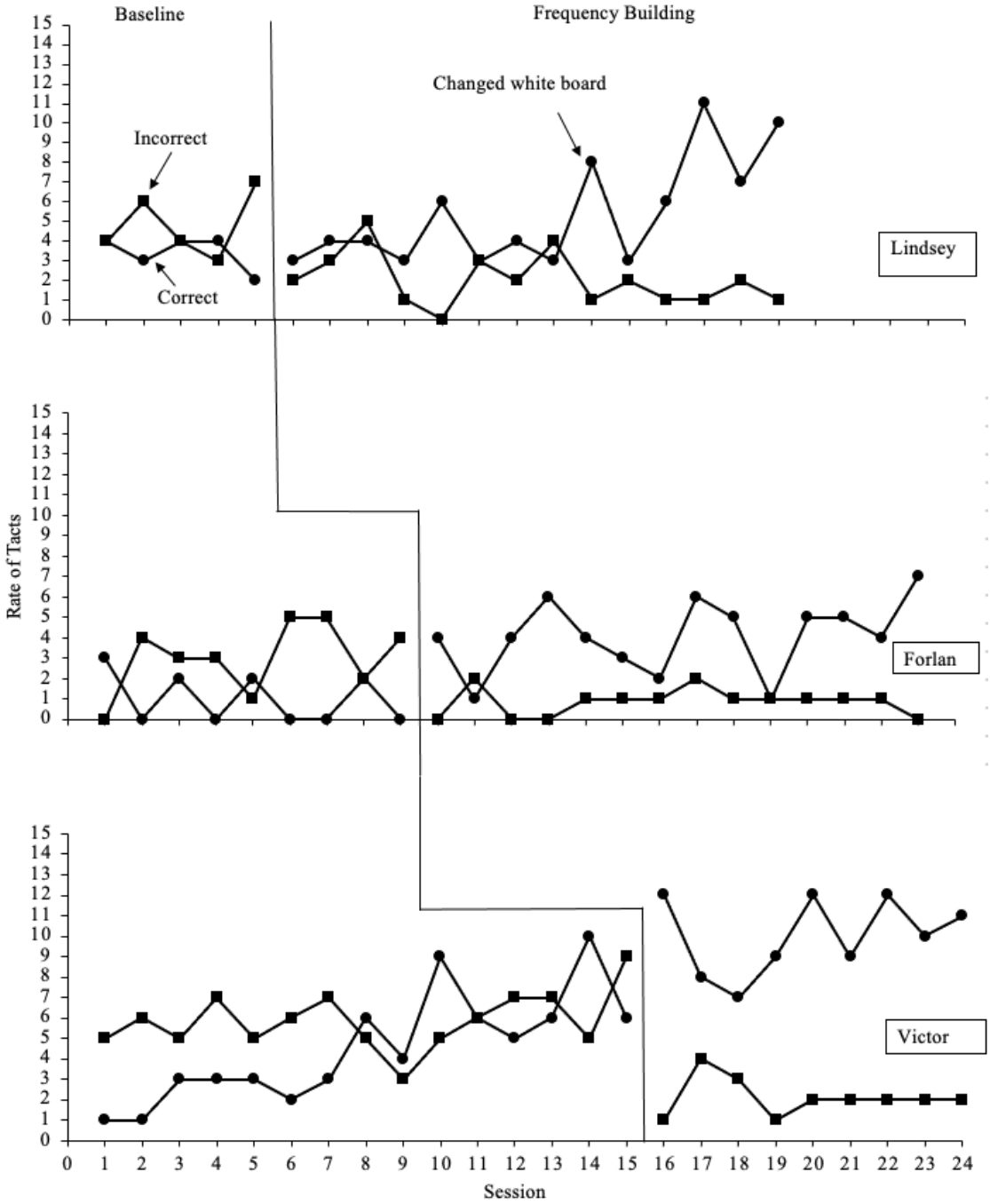
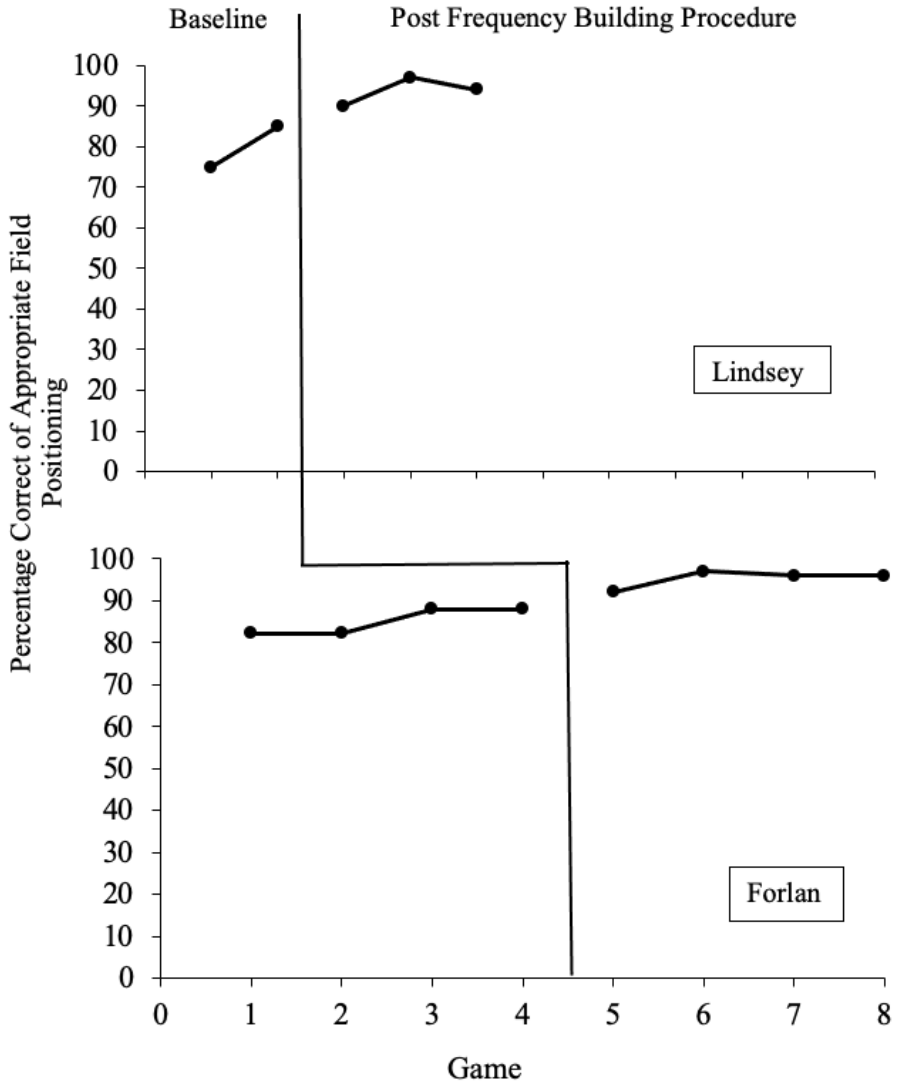


Figure 3

Percentage correct of appropriate field positioning during baseline and post frequency budling procedure (phase 2) for Lindsey and Forlan.



Appendix

PDC-Sports

Performance Diagnostic Checklist – Sports

Player's Name: _____ Interviewer: _____ Date: _____

Describe Performance Concern: _____

Instructions: Answer the questions below about the player's specific performance problem (not the player in general). The problem should be operationalized as either a behavioral excess or deficit. Items with an asterisk (*) should be answered only after the information is verified through direct observation.

TRAINING

1	❍ Yes ❍ No	Has the player received formal training on how to appropriately perform this skill? If yes, check all applicable training methods: ❍ Instructions ❍ Demonstration ❍ Rehearsal
2*	❍ Yes ❍ No	Can the player accurately describe the target skill and when it should be performed? *
3	❍ Yes ❍ No	Is there evidence that the player has accurately completed the skill in the past?
4*	❍ Yes ❍ No ❍ N/A	If the skill needs to be completed quickly, can the player perform it at the appropriate speed? *

TASK CLARIFICATION & PROMPTING

1	❍ Yes ❍ No	Has the player been informed that he/she is expected to perform the skill?
2*	❍ Yes ❍ No	Can the player state the purpose of the skill?
3	❍ Yes ❍ No	Is the player ever verbally, textually, or electronically reminded to complete the skill?
4	❍ Yes ❍ No	Is the task being performed in an environment well-suited for performance completion (e.g., not noisy or crowded)?

RESOURCES, MATERIALS, & PROCESSES

1*	❍ Yes ❍ No ❍ N/A	If materials (e.g., teaching stimuli, preferred items) are required for performance completion, are they readily available (e.g., easy to find, nearby)? If no materials are required, proceed to question 5. List materials below and indicate their availability. Item 1: _____ Item 2:

		_____ Item 3: _____ Item 4: _____
2*	❍ Yes ❍ No ❍ N/A	Are the materials necessary to complete the performance well designed for their intended purpose?
3*	❍ Yes ❍ No ❍ N/A	Are the materials necessary to complete the performance well organized for their intended purpose?

PERFORMANCE CONSEQUENCES, EFFORT, & COMPETETION

1	❍ Yes ❍ No	When is the player ever directly monitored by a coach one on one? If so, indicate the frequency of one-on-one monitoring. ❍ hourly ❍ daily ❍ weekly ❍ monthly ❍ Other: _____
2	❍ Yes ❍ No	Does the player ever receive feedback about the performance? If yes, indicate below. By whom? _____ How often? _____ Delay from skill? _____ Check all that apply: Feedback Focus: ❍ Positive ❍ Corrective Feedback Type: ❍ Written ❍ Verbal ❍ Graphed ❍ Other: _____
3	❍ Yes ❍ No	Does the player ever see the effects of accurate skill completion? If yes, how? _____
4	❍ Yes ❍ No	Is the skill simple or does it involve relatively low response effort?
5	❍ Yes ❍ No	Does the skill generally take precedence over other potentially competing skills? If not, indicate these competing skills below. Task 1: _____ Task 2: _____ Task 3: _____ Task 4: _____

INTERVENTION PLANNING

Instructions: Each item scored as *NO* on the PDC-Sports should be considered as an opportunity for intervention with priority given to areas in which multiple items are endorsed. Interventions may be implemented concurrently or consecutively. Sample interventions and illustrative literature citations for each area are provided below.

Area	Item #	Sample Intervention(s)	Literature Citations
Training	1, 2, 3, 4	Behavioral skills training (i.e., instructions, modeling, rehearsal, feedback)	• Barnes, Dunning, & Rehfeldt (2011) • Nabeyama & Sturmey (2010) • (Aiken, Fairbrother, & Post, 2012) • Gatewood, Feild, & Barrick (2008)
Task Clarification & Prompting	1, 2	Task clarification & checklists	• Cunningham & Austin (2007) • Gravina, VanWagner, & Austin (2008) • Bacon, Fulton, & Malott (1982)
	3	Prompts	• May, Austin, & Dymond (2011) • Petscher & Bailey (2006)
	4	Change/alter task location	• Green, Reid, Passante, & Canipe (2008)
Resources, Materials, & Processes	1,2,3	Improve access to, redesign, or reorganize task materials	• Casella, Wilder, Neidert, Rey, Compton & Chong (2010)
Performance Consequences, Effort, & Competition	1	Increased supervisor presence	• Brackett, Reid, & Green (2007) • Mozingo, Smith, Riordan, Reiss, & Bailey (2006)
	2	Performance feedback	• Arco (2008) • Green, Rollyson, Passante, & Reid (2002) • (Wolko, Hrycaiko, & Martin, 1993) • (Jennings, Reaburn, & Rynne, 2013)
	3	Regularly highlight task outcomes	• Methot, Williams, Cummings, & Bradshaw (1996)
	4	Reduce task effort	• Casella, Wilder, Neidert, Rey, Compton, & Chong (2010)
	5	Reduce aversive task properties	• Green, Reid, Passante, & Canipe (2008)

Appendix

Social Validity Survey

Please read these statements and bold or highlight a number to indicate your agreement. Please answer as honestly as possible.

1 = strongly disagree, 2 = somewhat disagree, 3 = neutral, 4 = somewhat agree

5 = strongly agree

1. I think the teaching procedure was effective when it comes to learning field positioning.

1 2 3 4 5

2. I liked the teaching procedure.

1 2 3 4 5

3. I think the teaching procedure will help me when I play in games.

1 2 3 4 5

4. I know more about the appropriate field position I should be in after the teaching procedure.

1 2 3 4 5

5. I liked receiving feedback from my coach during the teaching procedure.

1 2 3 4 5

6. It was easy to chart my progress during the teaching procedure.

1 2 3 4 5

7. I liked charting my progress.

1 2 3 4 5

8. I feel more confident about where I should be on the field during games.

1 2 3 4 5

9. If I had the opportunity to participate in this teaching procedure, I would do it again.

1 2 3 4 5

10. I believe the teaching procedure improved my field positioning during games.

1 2 3 4 5