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The effects of virtual coaching on olympic lift performance

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The Effects of Virtual Coaching on Olympic Lift Performance

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Abstract

Coaching in many forms, the most prevalent being in vivo coaching, helps to improve the performance of athletes across sports and exercise. The most natural next step in coaching is coaching through technology as opposed to in person; also known as virtual coaching. The present study sought out to examine the relative utility of two forms of virtual coaching on improving Olympic lift performance; video modeling and video feedback. A multiple baseline design across participants was used where one group of participants received video modeling intervention first, then video feedback, then both, while the second group received the video feedback intervention first, then video modeling, then both. Based on visual analysis, video modeling appeared to improve lift performance more so than video feedback, but less than the combined effects of video modeling and video feedback. The results suggest that video modeling could be a viable option for gym owners to implement in their gyms to allow for more coaching of athletes not involving a trainer and also add to the literature on video modeling.

Introduction

Since the beginning of behavior analysis, there has been an emphasis on consequence events to enact behavior change. These procedures involve a stimulus occurring after a target behavior which then changes the frequency of that behavior in the future (Ester & Winnet, 1982). Some common examples would be giving children an allowance for completing their chores. They must do their chores first, then they are presented with the money to increase doing chores in the future. The variable that is intended to change behavior occurs after the target behavior.

Another procedure used to enact behavior change would be antecedent strategies. Antecedent strategies involve the intervention coming *before* the target behavior that in turn enact behavior change. An example of an antecedent strategy would be posting hand washing directions above a sink in a public restroom. Antecedent interventions commonly employ two antecedent events to bring about a change in behavior; discriminative stimuli and motivating operations (Kern, Choutka, & Sokol, 2002). A discriminative stimulus (S^D) is a signal in the environment which is an indication to the organism that reinforcement is available upon the occurrence of the target behavior. A motivating operation (MO) is another environmental condition that alters the effectiveness of the consequence event and also affects the frequency of the target behavior that has previously been affected by that consequence (Cooper, Heron, & Heward, 2007). Antecedent interventions can use both S^Ds and MOs to drive people to enact behavior change.

Another example of an antecedent intervention used to enact behavior change is observational learning. It has been shown for decades that people will imitate the behavior of others through observational learning (Bandura, 1977). Through observational learning, imitation will occur with and without reinforcement (although motivation in some form is essential), across settings, and across activities. These activities include, but are not limited to, group therapy (Griffiths, 1974), generalized purchasing skills (Haring, Breen, Weiner, Kennedy, & Bednersh, 1995), phobias, and test anxiety reduction (Thelen, Fry, Fehrenbach, & Frautschi, 1979), functional skills in persons with developmental disabilities (Bellini & Akullian, 2007), and improvement of golf swings (Guadagnoli, Holcomb, & Davis, 1974). Observational learning, as well as other forms of antecedent interventions, rely on the history of reinforcement of the organism to enact behavior change. Specifically with observational learning, the organism is required to have an imitative repertoire that has been reinforced over such a long period of time a very thin schedule of reinforcement is required to enact behavior change (Deguchi, 1984). Observational learning is the process by which many forms of training or coaching work because it operates on the assumption that the trainee will be vicariously reinforced watching the trainer perform the exercise correctly (Deguchi, 1984). This then leads to the trainee imitating the behavior seek reinforcement by completing the exercise correctly as well. Observational learning is at the core of modeling, performance feedback, in vivo, and virtual coaching.

In vivo coaching

"In vivo" [Latin for "in the living" (Dictionary.com)] coaching is where an individual participates in the training by completing the target behavior themselves. When using in vivo coaching techniques, the participant usually has access to what the target behavior is supposed to be (notes, scripts, etc.) (Dempsey, Iwata, Fritz, & Rolider, 2012). A variation of in vivo coaching would be a live coach performing the target behavior for the participant to see *or* the participants engages in the desired behavior themselves as a point of reference for future performance. In vivo coaching is what is typically done in personal training sessions. With personal training, the trainer shows the client how to perform an exercise correctly by engaging in that exercise accurately. In other words, the trainer provides a model for the client. The trainer will also typically verbally explain the exercise to the client as he/she models. When the trainer is done, the client then performs the exercise and receives verbal feedback from the trainer on his/her performance. This would continue until the client performs the exercise correctly as determined by the trainer.

Although coaching in general can be used to improve techniques and performance, it can also be used to increase safety across a multitude of settings. Cox (1987) made it a point to highlight the issue of rising technological advances and how safety practitioners must be up to date on the latest technological trends to be able to teach others how to use them. Cox's point is also relevant for coaching in gym settings where coaches should be able to use today's technology to improve lift technique and therefore reduce the chance of injury in the gym. It has been reported that half a million people sustained an injury exercising or using exercise equipment in 2012 (www.legalmatch.com).

Bug-in-the-ear

If a live coach is unavailable, virtual coaching could be used because it involves techniques that do not require a person to be present to coach the participant, techniques such as the bug-in-the-ear technique, video modeling (VM), and video feedback (VF).

Bug-in-the-ear is a form of coaching that blends in vivo and virtual coaching which requires the trainee to use a hearing aid device so the trainer can talk them through the execution of the target behavior. Korner & Brown (1952) studied the usefulness of these devices and conducted a study on graduate students working with clients in a clinical setting where the direct observation and feedback of the supervisor interfered with the treatment process of the client with the trainee. Students were given 3-30 directions per minute from their supervisor via the bug in the ear (mechanical ear). The authors found the more mechanical ears were used, the easier they were to manage as evidenced by compliance by the graduate students to the feedback presented via the bug in the ear. Scheeler, Congdon, and Stansbery (2010) applied bug in the ear technology to classrooms by providing feedback via the mechanical ear to three dyads of co-teachers. Scheeler et al. used bug in the ear because providing verbal feedback in the classrooms would have been disruptive to the children. All three teacher dyads met mastery criteria on two dependent measures: command sequences to children (beginning with a question for the child, then the child's response, and ending with a follow-up from the teacher to the child) ease and usefulness of the bug in the ear technology as a social validity check. Not only did the results indicate the bug in the ear intervention was successful in these classrooms, but the teachers using the bug in the ear technology reported it was not uncomfortable and that they liked the immediate feedback without the classroom disruption that bug in the ear offers. These and other types of virtual coaching have the potential to be used in settings where it is not practical to have one-on-one coaching, or if an individual needs feedback specific to himself that does not relate to others being coached.

Bug in the ear, although a very effective form of feedback for most settings, would not be practical in the gym setting. Not only does the device involve wires and clips and having to stay in one place, but it also requires the setting to be quiet enough for the trainee to hear the trainer. Gyms are usually loud, and exercise more often than not requires movement with the potential to knock out an earpiece. In addition to these two impediments, bug in the ear still requires the same amount of personnel as typical in vivo coaching. It still requires either a trainer being present for each athlete or one trainer dividing their attention among many athletes.

Video Modeling

The second form of virtual coaching is video modeling. VM has grown out of Bandura's (1977) social learning theory and with technological advancements, is the natural next step in social imitation. In addition, with so many people in need of training services, the internet now allows trainers and coaches to disperse VM widely and easily. Charlop-Christy, Le, and Freeman (2000) used VM as opposed to in vivo training to teach children with autism new tasks. The results indicated that VM led to quicker acquisition of the new tasks across a variety of skills including imaginative play, spontaneous greetings, labeling of emotions, cooperative play, and daily living skills. Charlop-Christy et al. also found that when these tasks were taught using VM, the skills generalized to other people, settings, and stimuli but did not generalize when in vivo training was used. VM has also been found to be effective in teaching direct care staff members discrete trial training to use with children with autism (Catania, Almeida, Liu-Constant, & Reed, 2009). Staff members were scored on percent correct of a performance checklist, which broke down how to implement a discrete trial. As evidenced by visual analysis, when VM was implemented as an intervention, all three staff members improved their performance on the performance checklist. The students these staff members were serving also improved on the matching-to-sample task as a result of the improvement in the staff when VM was implemented.

Because one VM can be used to enact behavior change in many people at the same time, VM could be helpful in crowded environments such as gyms. Specifically, video techniques have been applied to CrossFit gyms. CrossFit is a conditioning program that aims to improve an individual's physical fitness in each of the 10 most recognized fitness domains: flexibility, strength, balance, endurance, power, speed, stamina, coordination, agility, and most important for the current study, accuracy (http://www.crossfitdefined.com/what-is-crossfit/). Another aspect of CrossFit is its universal scalability meaning athletes of all levels (amateur to expert) can participate.

Mulqueen (2014) used video modeling of an expert CrossFit athlete alongside video feedback of each participant's lift as an intervention to increase lift performance. These participants were shown the same model tape and were allowed to review the tape for up to 1 min. Verbal feedback was also given to each participant as part of normal CrossFit gym practice, but, no live modeling was done. All three participants improved their lift performance during and after the intervention as evidenced by the percent correct on a task analysis of the lift. Unfortunately, the relative effects of video modeling and video feedback cannot be untangled in Mulqueen's (2014) study because the video modeling and video feedback were a packaged intervention. For instance, a participant never experienced just video feedback without any influence of a prior condition.

Although there is evidence to suggest that in vivo coaching is effective (Conyers, et al., 2004, Dempsey, et al., 2012), in vivo coaching has many setbacks associated with its use that video modeling does not have. First, even though an advantage of in vivo coaching is that it does not take a lot of preparation (Dempsey et al, 2012), in many settings involving rigorous target behaviors such as gym settings, in vivo coaching would be more effortful than making a video model because it would be the difference between a coach performing the lift correctly one time on video or many times over and over in real time for each athlete in the gym. Second, in vivo training varies across each trial; there is no control over what the athlete will see over multiple sessions.

Conversely, a video model is able to regulate what is shown to each athlete. With systematic training, VM has been shown to take fewer trials to criterion with the same model as in vivo training (Dempsey et al, 2012). Third, in relation to the first point, in vivo training is difficult to implement with a large number of participants. Video modeling has the capability of being used across a large number of settings and people, as is usually the case in a gym setting.

Video Feedback

Video feedback, which has grown from performance feedback, is another form of virtual coaching after the target behavior has been performed. Performance feedback in general is effective in many scenarios. Performance feedback has been shown to improve the safety checklist implementation of pilots (Rantz, Dickinson, Sinclair, & Houten, 2009) and been shown to improve performance on a checklist associated with the supervising of clients (Green, Rollyson, Passante, Reid, 2002). Performance feedback can be useful in the proper implementation of behavior support plans in public schools

(Codding, Feinberg, Dunn, & Pace, 2005). Codding et al (2005) suggested that performance feedback, even not in video form, is an effective intervention when the staff providing feedback, time to give the feedback, and funds for video equipment for monitoring of participant behavior are available. However, when performance feedback is applied to sport settings, the results are much different. Stokes, Luiselli, Reed, and Fleming (2010) compared the effects of descriptive performance feedback to that of video feedback to improve pass blocking in high school football players. Stokes et al. found that descriptive feedback alone did result in an increase in number of steps completed correctly in a pass block. Descriptive performance feedback in addition to video feedback resulted in an increase in performance as visual analysis suggests.

McCullaugh, Ste-Marie, Law, Van Raalte, and Brewer (2014) reviewed the literature concerned with video technology applied to realistic sport settings, rehabilitation settings, and exercise settings. McCullaugh et al. found very little evidence of video feedback used in sport settings. However, one instance of VF improving performance in a sport, in this case golf, was when Guadagnoli, Holcomb, and Davis used a 3x3 (group x test) mixed design to investigate the effects of video feedback on golf swings. Thirty participants were randomly assigned to one of three groups (self-guided, verbal instruction, video instruction) and were tested once before the intervention and twice after the intervention. The two dependent measures were distance of golf balls and accuracy of swings. Each participants’ golf swing was analyzed using slow-motion video technology. All three groups were similar on the pre-test. Those in the self-guided group had no feedback given to them throughout the study. Those in the verbal feedback group received advice from a professional golfer. Finally, those in the video feedback group not only received the same verbal feedback as the previously stated group, but also received personalized video feedback after each session. Guadagnoli et al. found that those in the video feedback group performed better on both dependent measures at the second post-test than the verbal feedback group who did better than the self-guided group. The participants in the verbal and video groups actually demonstrated a negative impact from instruction at the first post-test. These results were reversed and performance got better after more instruction. Video feedback improved golf swings more than verbal feedback or no feedback even when the video group hit less golf balls than the verbal group and the self-guided group. Since each group practiced for the same amount of time, less time was dedicated to the actual golf swings when the instruction took more time (video group). The study also made a good point in stating that new golf swing techniques can sometimes take time to acquire and get used to and may not show up in assessments right away.

VM consists of a video of the target behavior performed as intended by either a professional or the individual in the study (video self-modeling or VSM). Video feedback (VF) consists of the individual in the study performing the target behavior as best they can, and immediately seeing a video of his/herself performing the behavior. VM and VF should be considered independent processes because in the latter technique there is no goal or video of the target behavior being performed as intended. Conversely, with VF, there is no personalized feedback for the individual.

Video technology, including but not limited to VF and VM, has recently been used in realistic sport settings to examine its effectiveness (McCullaugh, Ste-Marie, Law, Van Raalte, & Brewer, 2014). The current study aims to examine the effectiveness of video technology in a similar realistic sport setting and also to examine the use of various video imitation models (VM and VF as well as their combined effects) on Olympic lift performance of amateur CrossFit athletes (as there are no virtual coaching procedures to improve Olympic lift performance beyond in vivo coaching in the current literature). It was hypothesized that VM alone will improve lift technique more so than VF alone as VF will provide a possible incorrect model for the participant to imitate. It is also hypothesized that the combined effects (VMVF) will improve technique better than either individual technique as past research suggests (Mulqueen, 2014).

Method

Participants

Members of a CrossFit gym were recruited by a sign-up sheet at the front desk of the gym after an announcement was made of the study in various classes. Seven participants (6 women, 1 man) were selected from the sign-up sheet at random. The participants' ages ranged from 20 years old to 27 years old. All participants were regular athletes at the gym and wished to improve their lift performance. One participant (P18) was used as a pilot but was not able to attend all required sessions and their data was not included in the analysis.

Setting

Sessions took place at a CrossFit gym in Harrisonburg, Virginia. The gym consists of 15 rowing machines, a rig designed for pull-ups and racking the barbell during squats, a large open space, two bathrooms, one shower, a front desk, and storage cubes right inside the door of the gym. The space is approximately 2600 square feet. During sessions, a certified CrossFit coach was present for the entire time. Sessions were held during a barbell instruction course on Tuesday and Thursday evenings at 7pm for three consecutive weeks.

Materials

Videos were taken using the Iron Path™ application on a password protected Apple™ iPad and encrypted after data collection using the My Disk™ application. Videos were coded onto paper data sheets that were de-identified and stored behind a locked door.

Other materials included weightlifting materials such as a 35 pound barbell for women and a 45 pound barbell for men. Bumper plates of various weights were attached to either side of the barbell. Weights were secured with metal clips on either side.

Task Analysis

A 25 step task analysis of the lift "squat snatch" was completed with the help of two certified weightlifting coaches, a graduate faculty member at James Madison University, and three other graduate students also at James Madison. The analysis consisted of 25 steps. These steps were intended to break down the squat snatch lift into its smallest and most important parts that need to be done correctly to complete the lift safely. The steps include positions such as hip to shoulder positioning and having a straight back, as well as movements such as lifting the heels up off the ground and pulling the barbell to the hips. These 25 steps were grouped into larger movements within the lift including the set up position, pulls 1 and 2, extension, drop, recover, as well as miscellaneous steps relating to the path of the barbell. (Appendix A)

Procedure

A multiple baseline design across participants was conducted where the order of the interventions was counterbalanced across the two designs to account for order effects. The multiple baseline was used in an attempt to rule out alternative explanations. Each of the six participants were randomly assigned to one of two conditions (see below). Participants were instructed to attend the CrossFit gym as usual where, upon arrival, the coach explained to the class what the schedule was for the night. The coach allowed the athletes to stretch and warm up as they wish (usually no longer than 20 min). Instead of completing the assigned workout, each participant was asked to perform a snatch lift to be video recorded for this study.

Baseline data, the performance on each of the 25 steps, was taken for each participant for 41 to 50 lifts. The weight load used for each participant was 60-70% of his/her one rep maximum for the lift or if a one rep maximum was unknown a low, safe weight for beginners was used. This weight was unchanged throughout the study so change in weight would not be a confounding factor and would not influence lift performance.

Participants 104, 21, and 2225 went through three intervention phases after baseline in a staggered fashion. The first intervention consisted of the female participants watching a video model (VM) of a professional female athlete completing the lift at 100% accuracy and the male participant watching a VM of a professional male athlete completing the lift at 100% accuracy. Once the participant watched the video as many times as he/she liked, they were asked to perform that lift. They performed 10-15 lifts each session and had the video available to watch throughout the session. Each participant watched the video on average three times a session (or every third lift). The second intervention (VF) consisted of a video of the participant's previous lift being shown to them. This video changed for each lift because the participant was shown the lift that was most recently recorded. After they watched the video of themselves as many times as they wanted, they were then asked to perform the lift again. The third and final condition was a combination of the two previously stated conditions. The participant watched a video of his/her previous lift as well as a video of a professional completing the lift (VM+VF) on average every third lift, then performed the lift again.

Participants 22, 1112, and 138 went through an intervention package the same as the first intervention package above, except VF proceeded VM. The participants completed VF, then VM, then the combined VM+VF. In all cases every lift from each of the six participants was video recorded and the video was used to evaluate the completion of each of the 25 steps.

All participants received a free post-workout recovery drink that was purchased at the gym for their participation in the study.

Data Collection

One observer, a graduate student in the Psychological Sciences program at James Madison University, was present in the gym to show the participant the necessary videos, as well as to record the participants completing the appropriate lifts. The observer was trained on data collection procedures by viewing and analyzing videos of the snatch lift from the internet with live coaching from the researcher. This continued over multiple sessions until the data collector did not have any other questions and was able to analyze the videos with 100% agreement with the researcher.

Inter-Observer Agreement

Exact agreement IOA was conducted for 66% of total sessions by comparing the number of intervals both observers agreed upon and dividing that number by the total number of intervals (task analysis steps). The exact agreement IOA resulted in an average of 90% agreement between the researcher and the independent observer. The same observer used for data collection was used for data analysis and IOA.

Social Validity

To examine the social validity of this research, a CrossFit coach and a weightlifting coach were asked to independently rank each item on the task analysis into three groups: absolutely necessary in order to complete the lift, necessary but injury might occur if not done properly, and not necessary. The results, shown in Appendix B, indicate the items on the task analysis which the two coaches agreed upon in their ranking. 16 of the 25 items were agreed upon as being absolutely necessary or necessary. The ranking was done in order to confirm the necessity of each task analysis step.

Results

Figures 1 and 2 show the percent of task analysis steps completed correctly of the multiple baseline across participants design with Figure 1 beginning with VM and Figure 2 beginning with VF. As shown, there is no apparent systematic change in performance across participants until VM was applied to each participant, with the exception of P21. Performance was stable from the previous condition when VF was applied to each participant. The task analysis step completion for each participant are shown in Figures 3-8. In each figure the X axis is the number of the lift performed, the left Y axis is the number in the 25 step task analysis, and the right Y axis is the percent correct of the 25 steps.

The steps completed correctly (shaded boxes) and overall performance (percent correct) for P104 are depicted in Figure 3. Using visual analysis there appears to be a difference in performance from baseline to the VM condition. During VF, the data remain stable with the exception of one data point (19) which represents a lift that was dropped and not completed. The average percent correct of the task analysis steps is 82% in baseline. This increased to 95% correct in VM, then dropped to 90% correct in VF. It ended at 94% correct in VMVF. The steps completed correctly and overall performance for P21 are depicted in Figure 4. There is a decreasing trend throughout the baseline and VM conditions. Through VF the data are stable. In VMVF there is a clear increase in performance and a slight increasing trend. The average percent correct in baseline is 83%, 69% correct in VM, 66% correct in VF, and 86% correct in VMVF. The steps completed correctly and overall performance for P2225 are depicted in Figure 5. There is a clear increase in performance from baseline to the VM condition. The data in VF had a decreasing trend. Performance then increased again and stabilized throughout VMVF. The average percent correct in baseline is 62%, 91% correct in VM, 84% correct in VF, and 91% correct in VMVF. The steps completed correctly and overall performance for P22 are depicted in Figure 6. There is a slight increase in performance from baseline to VF. Then a marked increase from VF to VM, with an increasing trend in VM. VMVF produced data that are stable and at a high level. The average percent correct in baseline is 66%, 71% correct in VF, 83% correct in VM, and 97% correct in VMVF. The steps completed correctly and overall performance for P1112 are depicted in Figure 7. There is an increase in performance from baseline to VF, which has an increasing trend. VM and VMVF produced performance at a very high level with very little variability. The average percent correct in baseline is 88%, 94% correct in VF, 99% correct in VM, and 99% correct in VMVF. Lastly, the steps completed correctly and overall performance for P138 are depicted in Figure 8. There is no change in performance from baseline to VF which both produced stable data. There is a marked increase in performance during VM which remains throughout VMVF. The average percent correct in baseline is 59%, 61% correct in VF, 74% correct in VM, and 84% correct in VMVF.

When VM was implemented first, there was on average a 6.9% increase in lift performance with VM, on average a 4.3% increase in lift performance with VF, and on average a 17.9% increase in lift performance with VMVF. When VF was implemented first, there was on average a 2.9% increase in lift performance with VF, on average a 16% increase in lift performance with VM, and on average a 22.1% increase in lift performance with VMVF. The means were calculated by taking the average of the last five data points in each condition.

Visual analysis of the task analysis steps completed for each participant shows variability in the acquisition of specific steps in the task analysis. P104 gained the skill in the “Drop” step of the lift during VM and the first step of “Set up” was also gained during VMVF. P21 lost the skills of the “Drop” step of the lift during VM and these skills were then relearned during VMVF along with the last step in “Pull 1”. P2225 gained the skills of the “Drop” step of the lift during VM as well as proper shoulder and hip alignment and keeping a straight back. Proper shoulder and hip position, were not maintained throughout VF, but were then relearned during VMVF. P22 was consistent with most of the steps not achieved in baseline still not being achieved throughout VF. The skills in the "Drop" step of the lift were acquired toward the end of VM as well as proper shoulder and hip alignment and having hip contact with the bar. VMVF resulted in 100% accuracy the last five sessions. P1112 gained proper bar path during VF as well as proper hip and shoulder placement 5/9 sessions and VM and VMVF resulted in 99% accuracy of the task analysis steps. P138 did not consistently gain or lose any skills during VF. Halfway through VM, P138 acquired the skills in the "Drop" step of the lift. VMVF resulted in the acquisition of proper hip and shoulder placement and more consistent "Set up" skills as well for P138.

Discussion

It was hypothesized that the current study would result in VM producing higher performance on the 25 steps of the Olympic lift than VF as VF would provide an incorrect model for the participant to imitate, and VMVF producing higher performance than both VM and VF as previous research has shown the effect of VMVF together to be a significant increase in performance through visual analysis (Mulqueen, 2014). The results of this study confirm the hypotheses about virtual coaching. According to visual analysis, VM did improve lift performance more so than VF, and VMVF improved it more so than VM alone. The improvements in performance under VMVF could have been due to practice as this intervention was applied last to each participant. The improvements in VM could have been due to the fact that seeing the VM after a lift reinforced improved performance for future lifts. Although this was an antecedent intervention, the VM could have been a more effective and more salient consequence from previous lifts than VF which would also explain the increase in performance. Every participant in the study showed this pattern of results with the exception of P21.

The present results replicate previous research (Catania et al. 2009, Charlop-Christy et al. 2000) while simultaneously expanding on those results; specifically the results of Mulqueen (2014). The current study was able to tease apart the effects of each virtual coaching technique in a multiple baseline design as each session took place with all participants present while eliminating any possible effects of verbal feedback on lift performance. This informs the audience that it is possible that VF may not be needed, and that lift performance can increase with VM alone. VM videos can even be seen on the internet or a cell phone with an internet connection which makes them highly accessible to athletes and coaches. This point speaks to the practicality of the study in that these results could inform anyone with an internet connection as to the effectiveness of VM on performance so long as an appropriate model is available.

Appendix B illustrates the steps in the task analysis that two CrossFit and weightlifting coaches agreed upon as the most important steps in the squat snatch lift. In the present study, video modeling was shown to help improve performance in certain areas of the lift which include those skills in the “Drop” step of the lift, keeping a straight back, as well as overall shoulder-to-hip positioning. The skills in the “Drop” step and a straight back throughout the lift are imperative to have as coaches have reported some of the most important steps in the squat snatch lift are in the “Drop” step of the lift, keeping the back straight throughout multiple steps in the lift, and the correct angle at which the legs should be bent which affects shoulder and hip positioning (Appendix B).

Participant 21's pattern of results was not typical and there was a decrease during VM, stability through VF, and then increased slightly but not to baseline levels during VMVF. Several explanations for the pattern of behavior are plausible. The first explanation could be that even though the video model was presented to the participant, she may not have been looking at the video. The second explanation could be the sessions took place in a gym with people around and music playing so there were possible distractors in the environment. The first and second explanations are plausible to have led to the pattern of behavior seen in P21 as the participant engaged in conversation with other athletes in the gym throughout each data collection session. The third explanation is the participants did not have any clearly stated motivational contingencies (the access to a known reinforcer, avoidance of negative social consequences) which are necessary for participants to attend to the model and imitate the model (Bandura, 1977) aside from each participant wanting to improve their lift performance. The participants did not know they would be given a free recovery drink at the end of the study. Thus, attention to the model in this study could have potentially been lower than if the participants were aware there was a contingency in place. The fourth explanation could be that the results were due to fatigue. Although the times and days of data collection were held constant, the participants were free to exercise whenever they chose. Participant 21 did not report any fatigue throughout the course of the study so it is unlikely fatigue lead to the pattern of behavior seen. This leads to the fifth possible explanation which is that it is possible that for convenience, this participant chose to begin exercising before data collection sessions and then just be able to stay at the gym instead of having to leave and come back for the study. The sixth and last explanation is that the model in the video might not have been as similar to this participant and she was to the other female participants. The more similar the model is to the participant, the more likely they are to imitate (McCullaugh, 1987). It could take more than just gender for a participant to find similarities between themselves and the model. Interestingly, this participant also reached a new personal record with this lift after the study was completed. The participant lifted ten pounds more than they had ever lifted with the squat snatch lift. Had the intervention not improved their technique or performance, this might not have happened. However, given their data, it is not conclusive the PR was due to the intervention. This participant did self-report that she were likely to use these techniques in the future to continue to monitor and improve performance to reach even higher personal records.

An overall limitation found in this study was that data collection was based on time and not stabilization because the videos were analyzed at a later time than when data were taken. Spacing out the data collection could have helped against fatigue of the athletes (although there was no evidence of fatigue in the data, there was self-report of fatigue from the participants) as well as allowing more time for the videos to be analyzed in between sessions to determine the course of the study for each participant. However, this would have prolonged the length of the study which could have potentially lead to attrition of participants and more possibilities for lift practice outside of the study.

This study poses a solution to improving lift performance and it also poses possible solutions to increasing safety in gym settings as prevention of injury far exceeds the treatment of injury for many reasons including but not limited to misdiagnosis of injury and risk of re-injury (Sands, 2000). This is done through the use of proper technique while completing lifts or movements which can be accomplished through virtual coaching. Not only does the proper form of the lift need to be taught, Sands (2000) recommended several other factors be taken into consideration for the prevention of injury. One factor is the training volume used throughout practice. This would be the number of times a week an athlete would participate in the current study and the number of repetitions of the squat snatch lift the participants in this study had to complete. Sands kept the training volume at two times a week and a maximum of 15 repetitions in any one session. These, along with the light weight used for each participant, kept the training volume light. The other factor mentioned by Sands most pertinent to the current study is training intensity. The researcher took this into account by not asking the participants to complete a move they had never done before, complete the lifts at a high rate, or use a heavy weight throughout the study. By keeping the training volume and intensity at low levels throughout the study and suggesting this be done in future studies and coaching sessions, injury prevention was in effect.

The results of this study also have many practical implications not regarding safety for gym settings. In the near future, gyms should consider putting a television screen, or similar technology, in the gym with models performing various exercises on a loop continuously. This way, even when a trainer is not available to a client, the client will still be able to get the information that is needed to improve technique. The VM being available at all times would also be a low start-up cost and would be very durable across time. Other uses of technology could be phone applications, such as Iron Path™. The Iron Path™ application used in this study is widely available on smart phone devices and can track a number of aspects of each lift such as the path the barbell takes and the force at which the lift if being made. It does this by asking the user to specify where the barbell ends after recording a video. The application then maps a line following the barbell onto the video. This bar path line is helpful in examining the positioning of the athlete as a forward bar path indicates the athlete is leaning forward most likely due to a curved back and a backwards bar path indicates the athlete is leaning back most likely to do a hyperextended back.

The 25 step task analysis helps to show what movements specifically each participant was not performing prior to the intervention and which steps the intervention helped the athlete perform. An additional implication of these task analysis results is VM is more suitable for athletes training these specific movements that are lacking. As shown, VM can help athletes not only improve their overall lift performance, but it can also help fill in gaps in specific lift areas that the athlete is having trouble. For example, participant 1112 is a nationally ranked athlete and was still missing certain steps in the lift in the baseline condition. After VM however, 1112 began to perform the lift at 100% accuracy. This shows the universal nature of the intervention in that it can be applied to amateur CrossFit athletes as well as expert or nationally ranked athletes. This participant, however, would have benefitted from a more individualized model; a video model highlighting the specific areas that this athlete needed to work on. This would also cut down on trainer-athlete face time because once the trainer identifies the areas that are weak in the athlete's performance, a video model can be made targeting those skills.

Future studies could generalize the findings of improving one lift technique to other lifts. This could make training much more efficient if an athlete just has to improve on one lift instead of many to get similar results. Another direction could be to go from baseline to VMVF immediately. This would show us if the exposure to VM and/or VF alone before VMVF is necessary to get the increase in performance that was shown with VMVF in the current study. A final suggestion would be to target specific problem areas using VM as evidenced by the task list.

Figures

Figure 1. Video Modeling First Across Participants

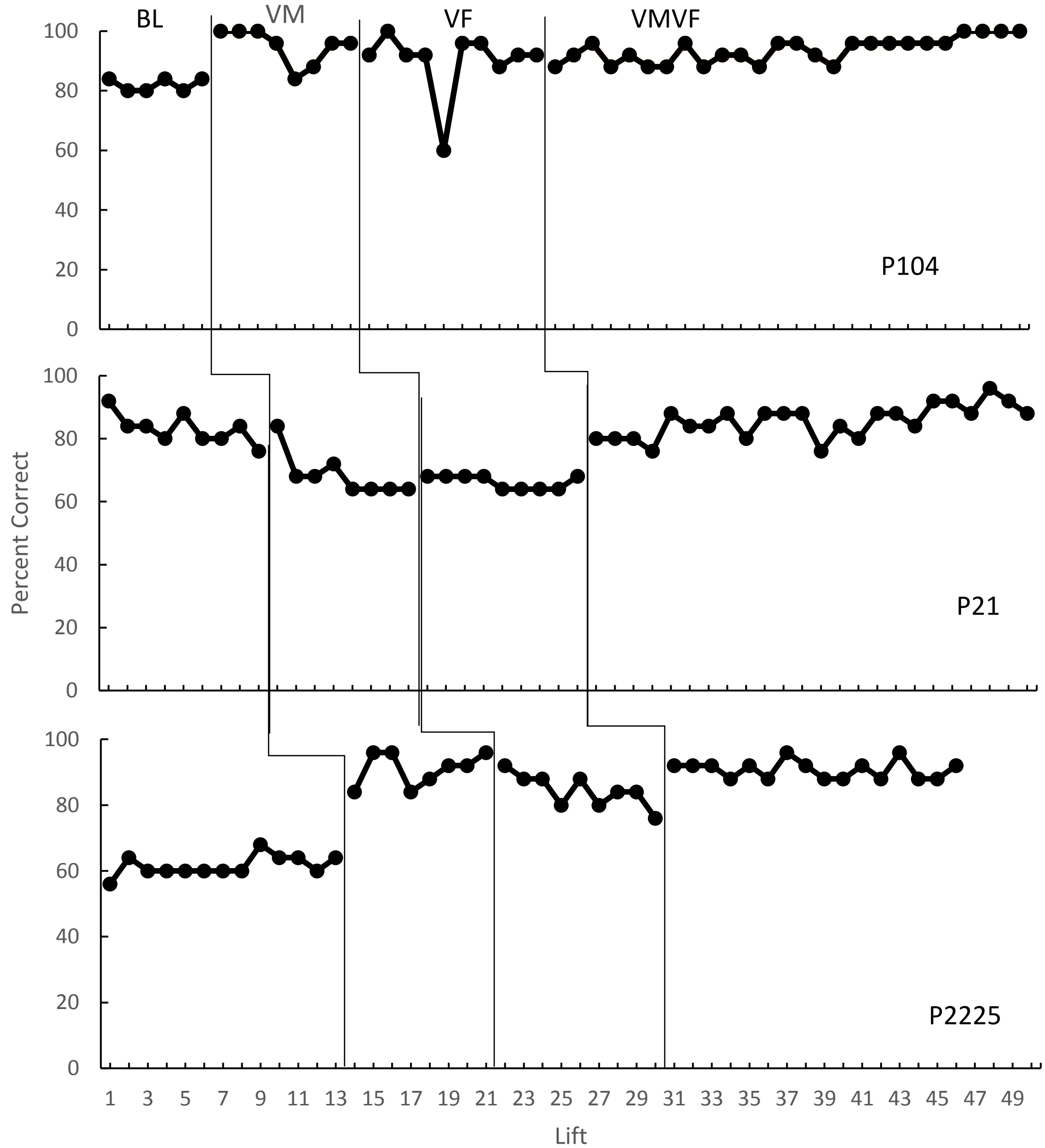

*Figure 1***.** Multiple baseline across participants of VM, VF, and then VMVF showing percent correct of 25 item task analysis for each lift.

Figure 2. Video Feedback First Across Participants.

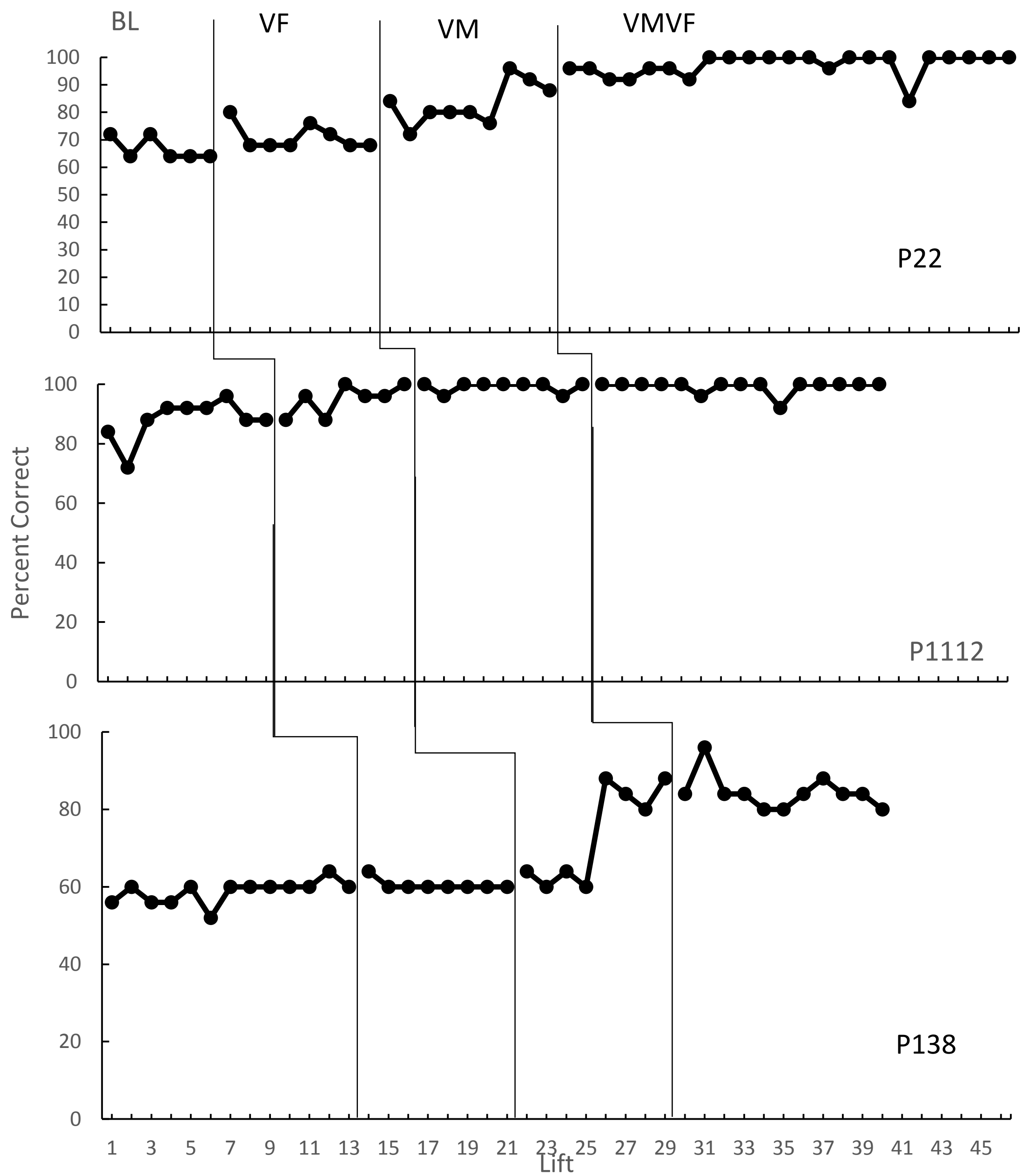

Figure 2. Multiple baseline across participants of VF, VM, and then VMVF showing percent correct of 25 item task analysis for each lift.

Figure 3. Data by Task Analysis Step P104.

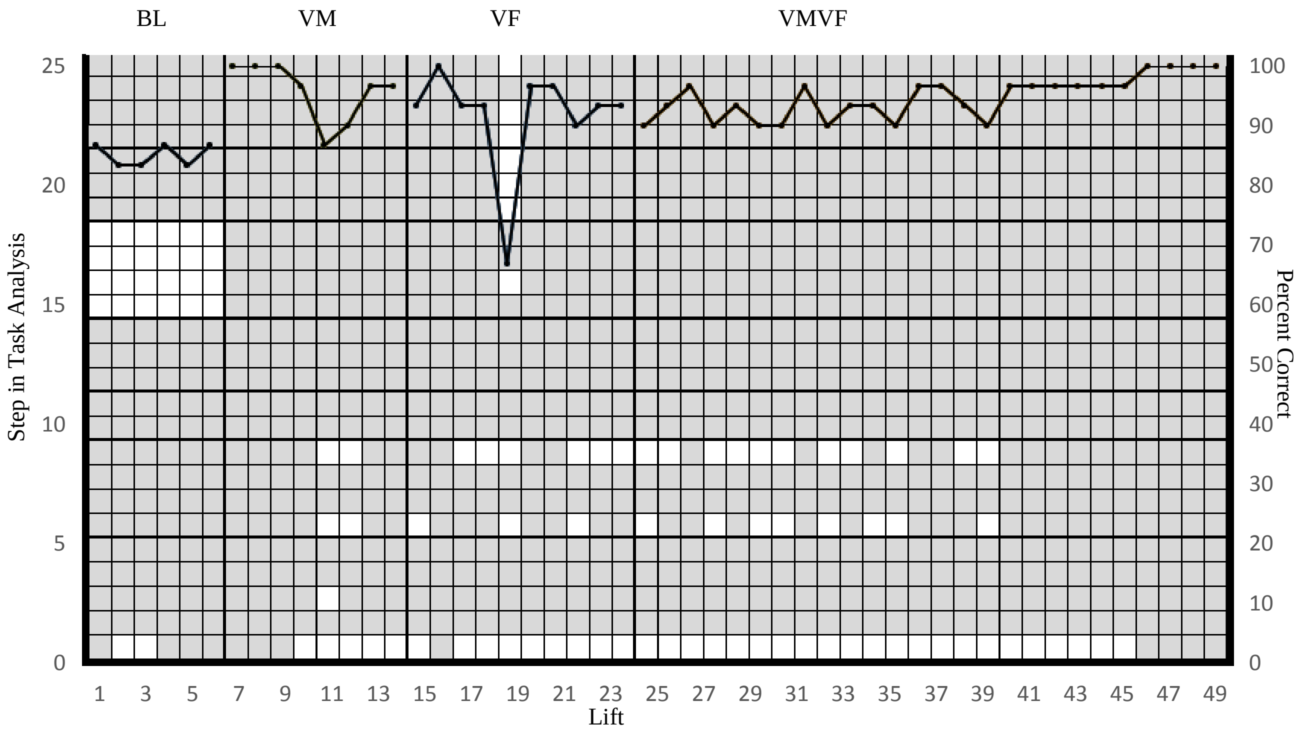

Figure 3. P104 break down of lift performance by task analysis steps as well as percent correct for each lift.

Figure 4. Data by Task Analysis Step P21.

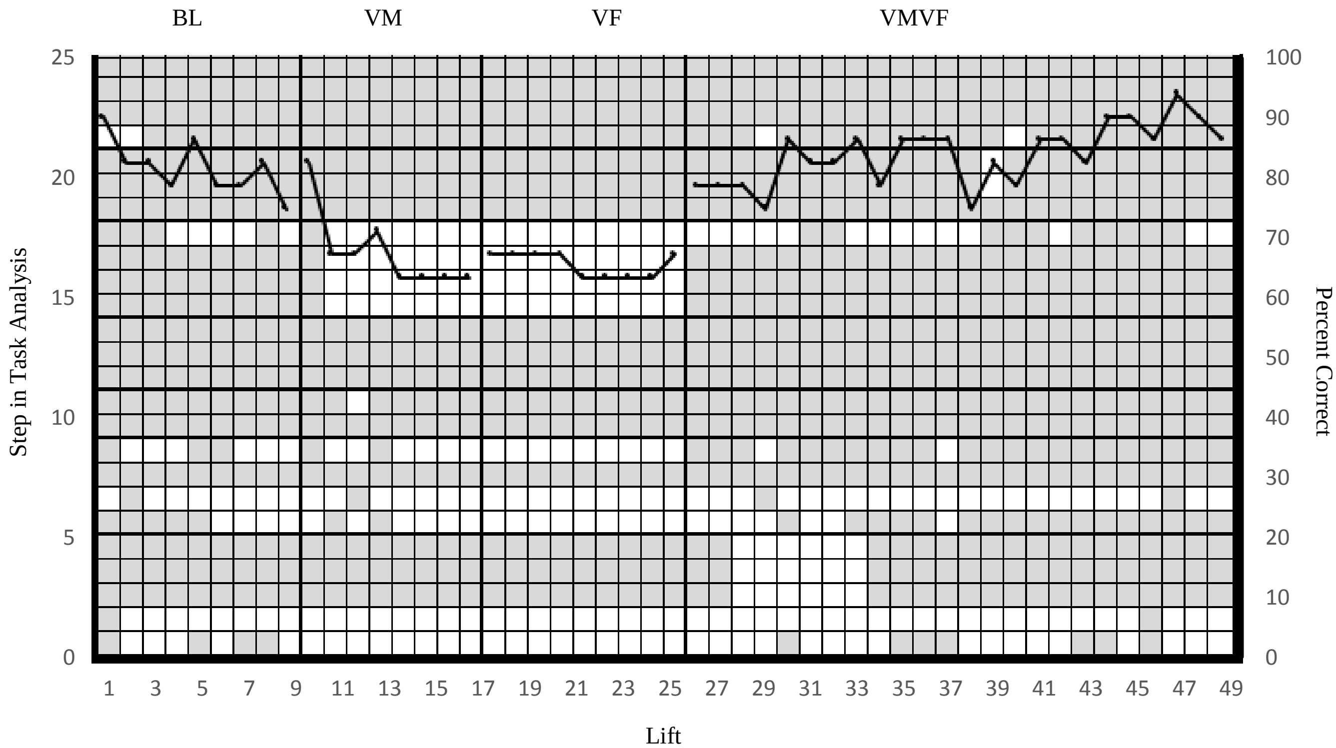

Figure 4. P21 break down of lift performance by task analysis steps as well as percent correct for each lift.

Figure 5. Data by Task Analysis Step P2225.

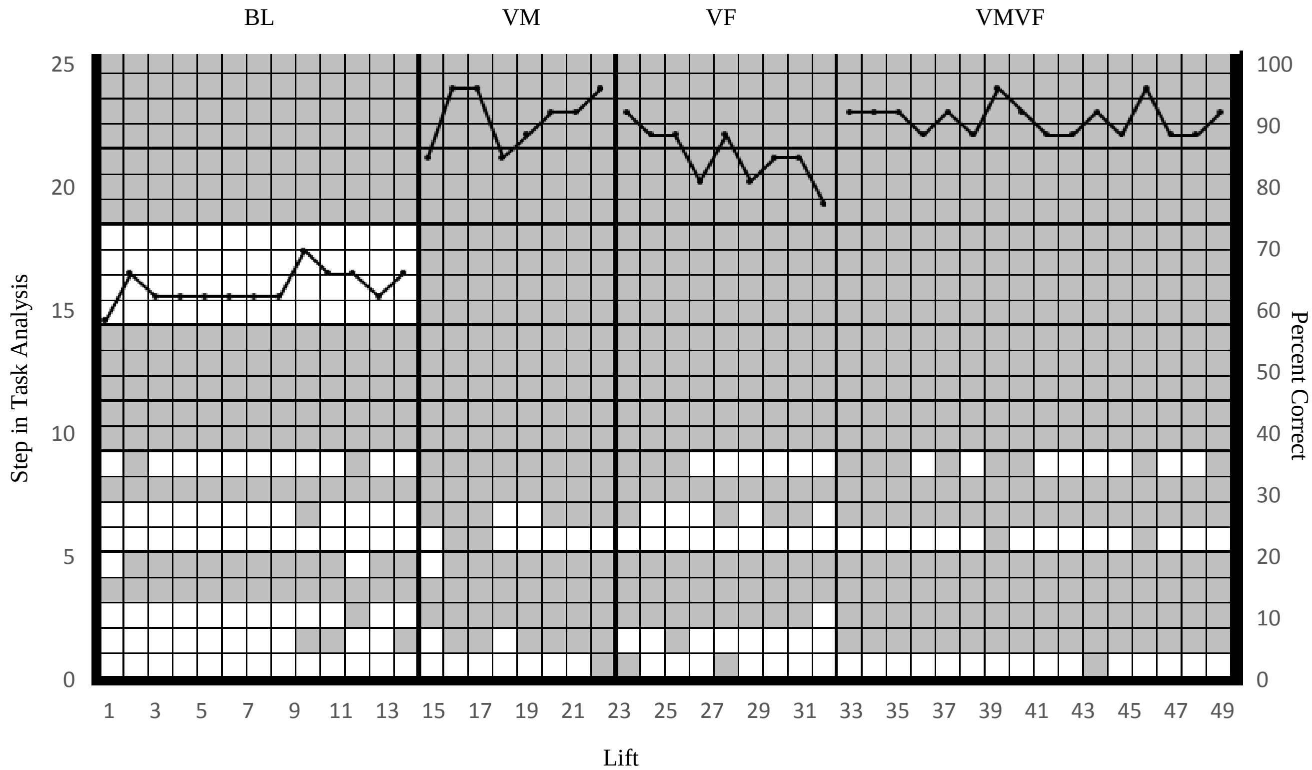

Figure 5. P2225 break down of lift performance by task analysis steps as well as percent correct for each lift.

Figure 6. Data by Task Analysis Step P22.

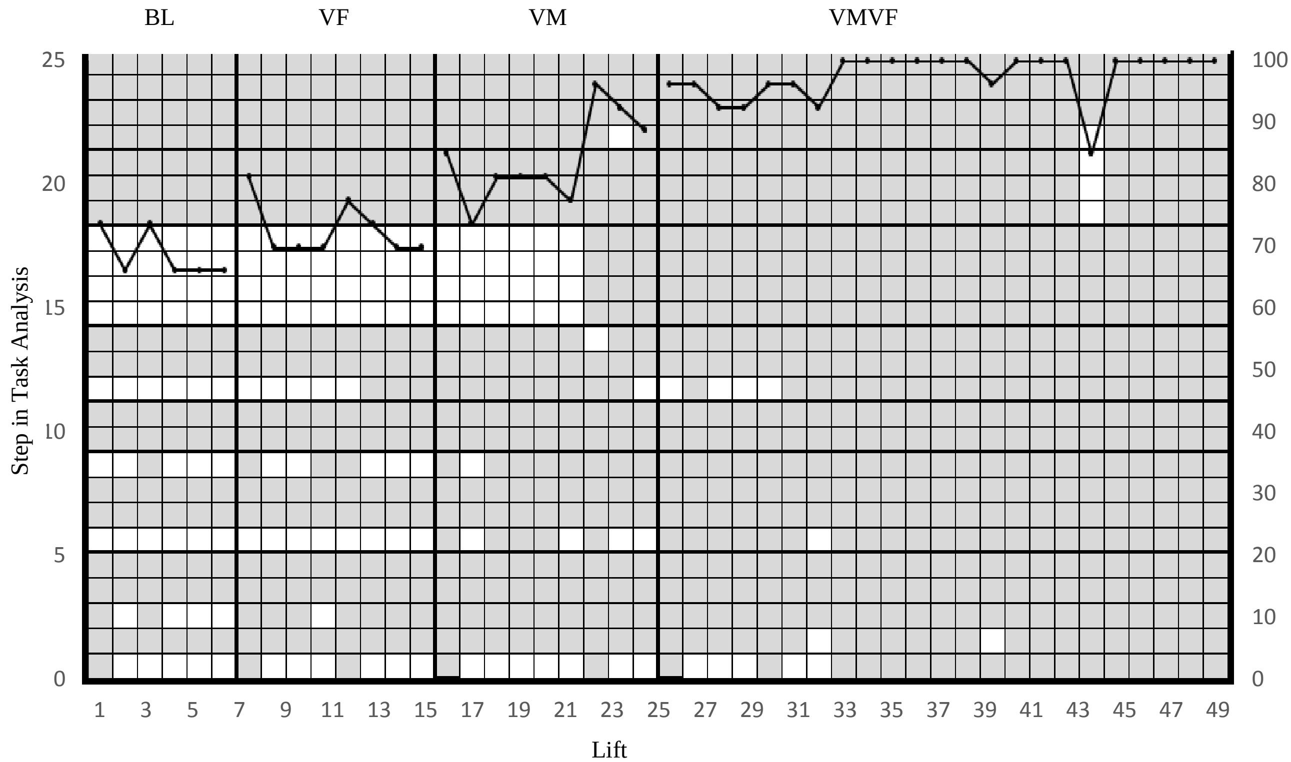

Figure 6. P22 break down of lift performance by task analysis steps as well as percent correct for each lift.

Figure 7. Data by Task Analysis Step P1112.

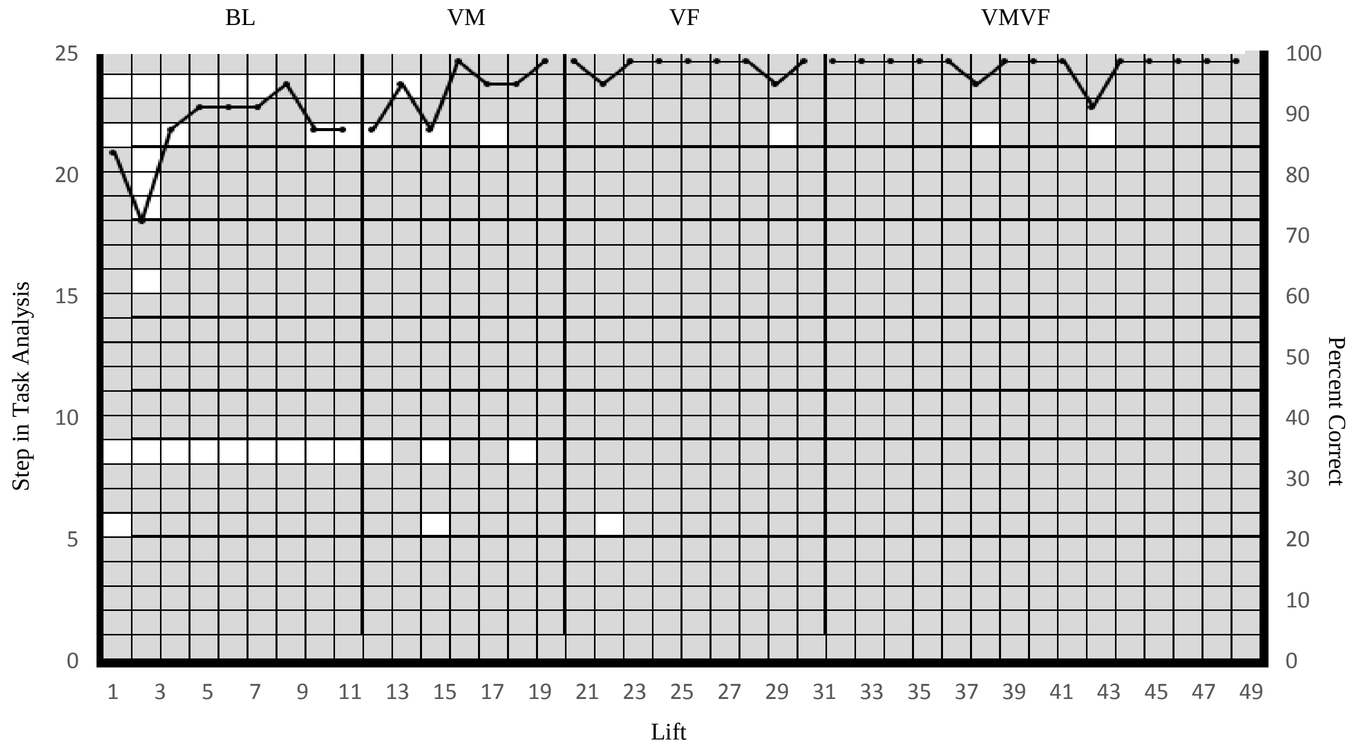

Figure 7. P1112 break down of lift performance by task analysis steps as well as percent correct for each lift.

Figure 8. Data by Task Analysis Step P138.

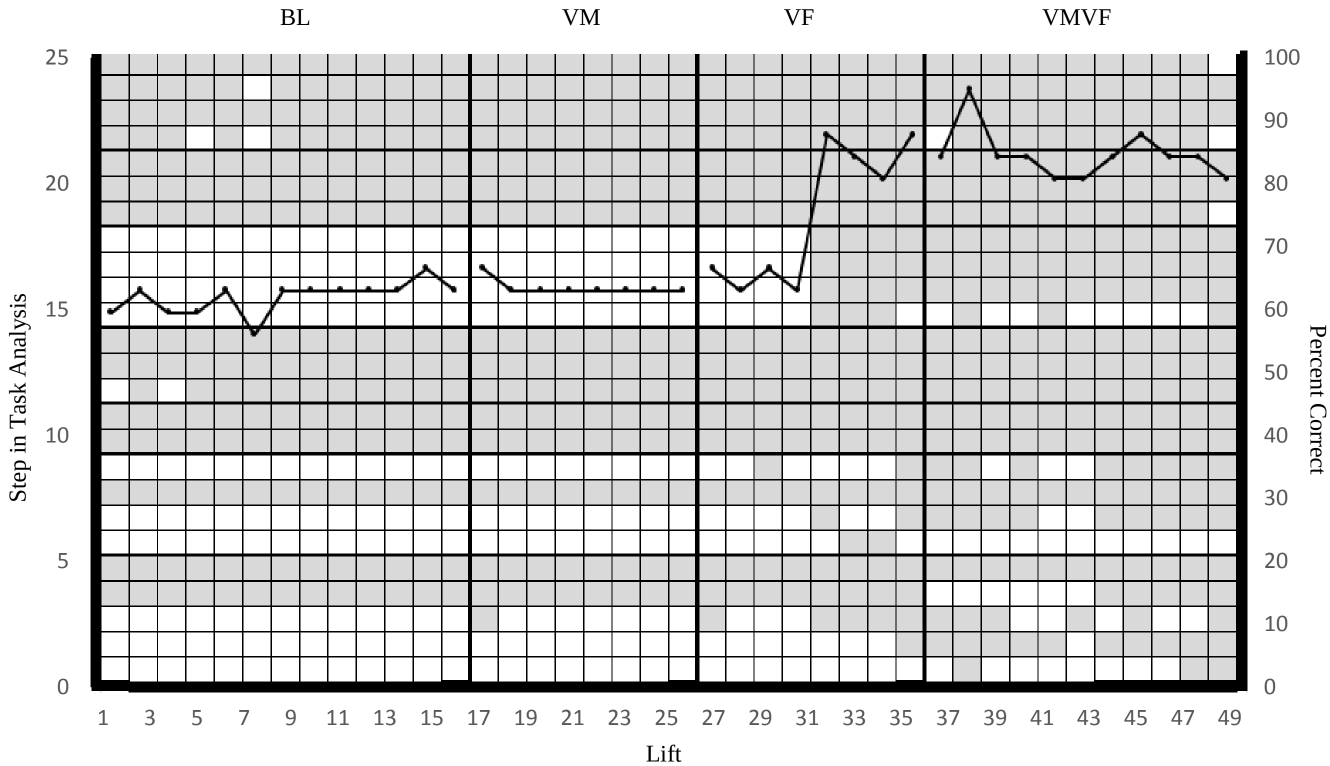

Figure 8. P138 break down of lift performance by task analysis steps as well as percent correct for each lift.

Appendix A

Task Analysis of Squat Snatch Lift.

Position	Description
Set up	Squat (hips at or below knees)
	Straight back
	Shoulders in line with knees
	Hands far outside knees on bar
	Head forward
Pull 1	Shoulders in line with knees
	Straight back
	Bar pulled to knees
	Legs bent (45-90 degrees)
Pull 2	Body vertical
	Bar pulled to hips
Extension	Hip extension/Contact with bar
	Feet leave ground/Heels up
	Shoulder shrug
Drop	Drop under bar to squat position (hips at or below knees)
	Arms locked out overhead
	Back straight
	Head forward
Recover	Stand up fully (legs straight) with bar overhead
	Arms locked out overhead
	Arms in line with or behind ears
Other	Bar path vertical
	Feet hip width
	Bar traces body
	Heels down until hip extension

Appendix B

The agreed upon rank of necessity for steps in the 25 step task analysis in the squat snatch lift. The rankings are presented in the third column.

Set Up	Squat (hips at or below knees)	
	Straight back	Absolutely Necessary
	Shoulders in line with knees	
	Hands far outside knees on bar	Necessary
	Head forward	Necessary
Pull 1	Shoulders in line with knees	
	Straight back	Absolutely Necessary
	Bar pulled to knees	
	Legs bent (45-90 degrees)	Necessary
Pull 2	Body vertical	Absolutely Necessary
	Bar pulled to hips	
Extension	Hip extension/Contact with bar	
	Feet leave ground/Heels up	
	Shoulder shrug	Necessary
Drop	Drop under bar to squat position (hips at or below knees)	
	Arms locked out overhead	Absolutely Necessary
	Back straight	Absolutely Necessary
	Head forward	Necessary
Recover	Stand up fully (legs straight) with bar overhead	Absolutely Necessary
	Arms locked out overhead	Absolutely Necessary
	Arms in line with or behind ears	Necessary
Other	Bar path vertical	Absolutely Necessary
	Feet hip width	
	Bar traces body	Necessary
	Heels down until hip extension	Necessary

References

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.

Bellini, S., & Akullian, J. (2007). A meta-analysis of video modeling and video self-modeling interventions for children and adolescents with autism spectrum disorders. *Exceptional Children, 73*(3), 264-287.

Catania, C. N., Almeida, D., Liu-Constant, B., & Reed, F. D. D. (2009). Video modeling to train staff to implement discrete-trial instruction. *Journal of Applied Behavior Analysis*, *42*(2), 387-392.

Charlop-Christy, Marjorie H., Loc Le, and Kurt A. Freeman. (2000). "A comparison of video modeling with in vivo modeling for teaching children with autism. *Journal of Autism and Developmental Disorders, 30(6),* 537-552.

Codding, R. S., Feinberg, A. B., Dunn, E. K., & Pace, G. M. (2005). Effects of immediate performance feedback on implementation of behavior support plans. *Journal of Applied Behavior Analysis*, *38*(2), 205-219.

Conyers, C., Miltenberger, R. G., Peterson, B., Gubin, A., Jurgens, M., Selders, A, & Barenz, R. (2004). An evaluation of in vivo desensitization and video modeling to increase compliance with dental procedures in persons with mental retardation. *Journal of Applied Behavior Analysis, 37(2),* 233-238.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). Applied behavior analysis.

Cox, S. (1987). Safety training: An overview of current needs. *Work & Stress, 1*(1), 67-71. doi:10.1080/02678378708258484

Deguchi, H. (1984). Observational learning from a radical-behavioristic viewpoint. *The Behavior Analyst*, *7(2)*, 83-95.

Dempsey, C. M., Iwata, B. A., Fritz, J. N., & Rolider, N. U. (2012). Observer training revisited: A comparison of in vivo and video instruction. *Journal of Applied Behavior Analysis*, *45*(4), 827-832.

Ester, P., & Winnet, R. A. (1982). Toward more effective antecedent strategies for environmental programs. *Journal of Environmental Systems*, *11*(3), 201-222.

Green, C. W., Rollyson, J. H., Passante, S. C., & Reid, D. H. (2002). Maintaining proficient supervisor performance with direct support personnel: An analysis of two management approaches. *Journal of Applied Behavior Analysis*, *35*(2), 205-208.

Griffiths, R. D. P. (1974). Videotape feedback as a therapeutic technique: Retrospect and prospect. *Behaviour Research and Therapy*, *12*(1), 1-8.

Guadagnoli, M., Holcomb, W., & Davis, M. (2002). The efficacy of video feedback for learning the golf swing. *Journal of Sports Sciences*, *20*(8), 615-622.

Haring, T. G., Breen, C. G., Weiner, J., Kennedy, C. H., & Bednersh, F. (1995). Using videotape modeling to facilitate generalized purchasing skills. *Journal of Behavioral Education*, *5(1),* 29-53.

In vivo. In *Merriam-Webster Dictionary online.* Retrieved from http://www.merriam-webster.com/dictionary/in%20vivo

Kern, L., Choutka, C. M., & Sokol, N. G. (2002). Assessment-based antecedent interventions used in natural settings to reduce challenging behavior: An analysis of the literature. *Education and Treatment of Children*, 113-130.

Korner, I. N., & Brown, W. H. (1952). The mechanical third ear. *Journal of Consulting Psychology*, *16(1),* 81-84.

McCullagh, P. (1987). Model Similarity Effects on Motor Performance. *.Journal of Sport Psychology*, *9(3),* 249-260.

McCullagh, P., Ste-Marie, D., Law, B., Van Raalte, J. (Ed) Brewer, Britton W. (Ed), (2014). *Exploring Sport and Exercise Psychology* (3rd ed.), 139-162.

Mulqueen, D. (2014). Using Video Modeling and Video Feedback to Improve Olympic Weightlifting Technique.

Rantz, W. G., Dickinson, A. M., Sinclair, G. A., & Houten, R. V. (2009). The effect of feedback on the accuracy of checklist completion during instrument flight training. *Journal of Applied Behavior Analysis*, *42(3)*, 497-509.

Sands, W. A. (2000). Injury prevention in women's gymnastics. *Sports Medicine*, *30(5),* 359-373.

Scheeler, M. C., Congdon, M., & Stansbery, S. (2010). Providing immediate feedback to co-teachers through bug-in-ear technology: An effective method of peer coaching in inclusion classrooms. *Teacher Education and Special Education: The Journal of the Teacher Education Division of the Council for Exceptional Children*, *33(1),* 83-96.

Stokes, J. V., Luiselli, J. K., Reed, D. D., & Fleming, R. K. (2010). Behavioral coaching to improve offensive line pass-blocking skills of high school football athletes. *Journal of Applied Behavior Analysis*, *43(3)*, 463-472.

Thelen, M. H., Fry, R. A., Fehrenbach, P. A., & Frautschi, N. M. (1979). Therapeutic videotape and film modeling: a review. *Psychological Bulletin*, *86(4)*, 701-720.

http://www.crossfitdefined.com/what-is-crossfit/

http://www.legalmatch.com/law-library/article/gym-accident-statistics.html