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An Evaluation of Video Feedback with and without Video Modeling to Enhance Barbell Squat Form

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by

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ABSTRACT

Previous studies have assessed the use of video interventions to enhance athletic performance. However, few studies have evaluated the use of video interventions to improve form in weightlifting. The present study evaluated the effects of video feedback (VF) with and without video modeling (VM) to enhance barbell squat form with novice and typically developing adults. The results showed that VF increased performance to near 100% for one participant. For the other VF increased performance to moderate levels and the addition of VF only slightly increased performance

CHAPTER ONE:

AUTHORS NOTE

Due to the COVID-19 pandemic the thesis requirements for students graduating from the USF ABA program in 2021 has been modified and may include fewer participants, case studies, or literature review. This study was completed as a thesis by the first author. Thank you to Carlos Abarca, Victoria Brown, and Mallamy Camargo-Pena for help with data collection.

Introduction

Researchers have demonstrated the use of video interventions to enhance athletic performance in a variety of sports (e.g., BenitezSantiago & Miltenberger, 2016; Downs et al., 2015; Jennings et al., 2013; Post et al., 2013). Video modeling (VM) and video feedback (VF) are two interventions that use video technology. Video modeling involves the target individual viewing a video recording of an individual demonstrating how to perform a behavior correctly (Schenk & Miltenberger, 2019). The target individual can serve as their own model by recording themselves performing the correct response (e.g., Dowrick & Dove, 1980). However, it is more common for an expert (e.g., athlete or trainer) to serve as a model (Boyer et al., 2009). During VF, the target individual views a video recording of themselves performing the target behavior and the researcher provides feedback by delivering praise for steps performed correctly and corrective comments for steps performed incorrectly (Schenk & Miltenberger, 2019). Video recordings can be viewed immediately on the recording device (e.g., tablet; Kelley & Miltenberger, 2016) or uploaded from the recording device (e.g., digital camera) to an external device (e.g., laptop) to display a larger video or to enable control features (i.e., pause, play, fast-

forward, and rewind) that may not be available on the recording device (BenitezSantiago & Miltenberger, 2016).

The use of VF and VM have been assessed as individual and combined interventions in a variety of sports. These sports include martial arts (BenitezSantiago & Miltenberger, 2016), horseback riding (Kelley & Miltenberger, 2016), volleyball (Zetou et al., 1999; Zetou et al., 2002), gymnastics (Baudry et al., 2006; Boyer et al., 2009), track and field (Maryam et al., 2009), dance (Quinn et al., 2020), and weightlifting (Carter et al., 2017; Mulqueen et al., in press).

Some studies have examined VF alone. BenitezSantiago and Miltenberger (2016) assessed the effects of VF on three martial art movements with adults who had some experience with martial arts. Researchers demonstrated VF led to moderate increases in performance. In some cases, VF was delayed due to video uploading times. It is unknown if delayed feedback explains only modest increases demonstrated. Kelley and Miltenberger (2016) evaluated VF on horseback-riding form with experienced horse riders. Unlike BenitezSantiago and Miltenberger (2016), VF was delivered to riders immediately after each performance. Results showed that VF substantially increased correct riding skills of experienced riders. Results from both studies suggest that VF is useful in improving athletic performance but may require immediacy to produce substantial improvement in performance.

Few studies evaluated VM alone. Maryam et al. (2009) evaluated VM to increase hammer throw and the discus throw performance for track and field. Researchers showed that participants that received VM increased their performance for both skills more than participants who received verbal instruction. More recently, Quinn et al. (2020) examined the effects of VM alone prior to implementing VM with VF on the acquisition of a ballet movement with

adolescents. Researchers showed that VM alone produced small improvements in performance of the ballet movement across participants. However, VM combined with VF produced substantial increases in performance. These results suggest that VM in isolation may not be effective for increasing athletic performance and may require a supplemental intervention to effectively improve athletic performance. These results also suggest that VM supplemented with VF is beneficial in improving performance.

Several other studies have also evaluated VM and VF as a combined intervention. For example, Boyer et al. (2009) used VM and VF to improve performance with competitive gymnasts. Researchers showed gymnasts' a video recording of an expert model prior to their attempts to complete target gymnastic movements, followed by VF after each performance. There were immediate but slight and modest increases in gymnasts' skills from baseline to intervention. Additionally, researchers demonstrated that participants were able to maintain their gymnastic performance above baseline levels when assessed during weekly follow-ups. In a similar study, Baudry et al. (2006) evaluated the effects of VM and VF on technique of circle on the pommel-horse skill with gymnasts. Results showed that gymnasts' in the VM with VF group improved technique more than a group that received no VM with VF.

Other studies have directly compared VF and VM in isolation. For example, Zetou et al. (1999, 2002) examined VF and VM on pass, setting, and serving skills used in volleyball. Volleyball players were assigned into either a VF or VM group. Results showed that participants in the VM group improved their volleyball skills more than participants in the VF group for pass and setting skills. There was not a differentiation between groups for the serve skill. The results are potentially confounded due to inclusion of verbal instruction in both groups. Thus, it is unknown if VM and VF were solely responsible for the results because verbal instruction was

not assessed separately. However, the results of this study suggest VM may be more beneficial or equal to the effects of VF for certain types of athletic skills.

Although several studies have evaluated VM and VF to enhance athletic performance, the results are mixed with some studies showing VM alone is effective (e.g., Maryam et al., 2009; Zetou et al., 1999, 2002) and others showing it has limited effectiveness (e.g., Quinn et al., 2020). Additionally, the results of VF are mixed with some studies demonstrating modest increases in performance (BenitezSantiago and Miltenberger, 2016), while others produced substantial increases in performance (Kelley and Miltenberger, 2016). Although the use of VM and VF as a combined intervention has been shown to be effective (e.g., Boyer et al., 2009), it is unknown if the addition of VM produces further increases in performance. More research evaluating these procedures is needed in the sports literature. Despite that VM and VF have been researched in a variety of sports, few studies have applied these interventions to weightlifting.

According to the Center of Disease Control, approximately 20% of adults partake in strength training as recommended by health officals (Blackwell & Clarke, 2018). Weightlifting is a type of strength training that focuses on lifting barbells or other weights (e.g., dumbbells; Britannica, 2016). Individuals may participate in weightlifting as a preventive method to reduce risk of specific health conditions such as obesity or osteoporosis. Weightlifting may also help individuals obtain and maintain good health or achieve aesthetic goals such as building lean muscle tissue (Winett & Carpinelli, 2001). Only a small number of studies have evaluated VM and VF to enhance weightlifting performance. Carter et al. (2017) evaluated the effects of VM with the addition of praise to teach three weightlifting movements to adults diagnosed with down syndrome. The researchers described that they chose lifts that were similar to daily living skills the participants were naturally required to complete routinely. Results showed only slight

improvements across lifts for all participants after VM was implemented. Additionally, participants were able to maintain performance above baseline levels across lifts at follow-up sessions that occurred weeks later. There are a couple variables to consider when interpreting these results. First, praise was not assessed by itself so it is unknown if the absence of praise would have yielded different results. Second, Down syndrome is a chromosomal disorder that is characterized by strength deficits (Morris et al., 1982). As Carter et al. (2017) described, participants may have had physical limitations that restricted them from accurately performing the lifts to a certain degree. Thus, it is unclear whether the results of the study were impacted by the physical limitations of the participants. Despite these variables, the results of the study are consistent with the VM phase in Quinn et al. (2020) and suggests that VM in isolation has limited effects and may need to be combined with video or verbal feedback to further improve performance. To the authors knowledge, only one study has evaluated VM combined with VF to enhance weightlifting performance. Mulqueen et al. (in press) demonstrated immediate and substantial improvement in weightlifting performance for the snatch and clean and jerk when VM and VF was implemented. Additionally, all weightlifters maintained performance when assessed during follow-up sessions that researchers conducted up to 6-weeks after the intervention was withdrawn. Although the effectiveness of VM and VF in this study differ from the limited improvements demonstrated by Boyer et al. (2009), they are consistent with the results achieved by Quinn et al. (2020) in the VM and VF phase. Overall, these results suggest that VM and VF combined are helpful in improving weightlifting technique.

The barbell squat is a traditional movement in weightlifting. Although there are different variations of the barbell squat, this study will focus on barbell back squat form. Ensuring correct barbell squat form may reduce risk of injury and may be prerequisite to more complex

weightlifting movements. Weightlifters often prioritize lifting maximal loads (Stromback et al., 2018) and may sacrifice correct form to do so. In turn, this can lead to severe injury. Injuries due to improper form are common to the back and knees (Fry et al., 2003). Myer et al. (2014) identified errors that individuals often make when performing barbell squats such as caving knees inward, raising heels or toes off of the ground, and rounding of the back. In addition, mastering correct barbell squat form may be prerequisite to increasing weight load or performing more fluid weightlifting movements such as the clean and jerk.

Although VM and VF combined has been documented to improve weightlifting performance, VF on its own would be more efficient than combined with VM. Additionally, VF may be more preferred by participants than a treatment package (Stokes et al., 2010). However, no study to the author's knowledge has evaluated VF to improve weightlifting performance. Additionally, no study in the sports performance literature has evaluated VF followed by VM combined with VF yet. Thus, the purpose of this study was to evaluate the effects of VF on barbell squat form with adults who were typically developing and novices to weightlifting. Additionally, this study evaluated VF with VM if VF alone did not substantially improve barbell squat form.

CHAPTER TWO:

METHOD

Participants and Setting

Three typically developing adults that were novices to weightlifting and expressed interested in improving their barbell squat form were recruited to participate in this study. Kate was a 19-year-old female that attended a gym intermittently across one month to use equipment including the treadmill and weight machines. Kate reported that she had experience with performing body weight squats but did not have experience with barbell squats. John was a 28-year-old male that did not have any experience with performing barbell squats. Jane was a 26-year-old female that frequently engaged in low-to-moderate intensity cardio (e.g., walking) and occasionally lifted light free weights such as dumbbells. The participants were recruited via a flyer posted to the primary researcher's social media accounts and word-of-mouth. The researcher described the study and asked that the potential participants contact the primary researcher if interested in further details.

The primary researcher met with the participants individually to describe inclusion and exclusion criteria, review the consent form, and to provide opportunity for questions. The participants were included in this study if they were interested in improving their barbell squat form, were between the ages of 18-35, and were able to lift at least 45 lb. The consent form included sections describing procedures, setting, potential risks and benefits of procedures, confidentiality, and ability to withdraw of consent at any time. Each section was reviewed with all participants. Additionally, participants were asked to check one of two boxes on the consent form to either agree or disagree to be video recorded during sessions. Although precautions were

taken to minimize risk during the COVID-19 Pandemic, the primary researcher informed participants of the potential transmission of COVID-19 during this study. Precautions that were taken include mask wearing, cleansing hands as needed, standing 6 feet apart, and sanitizing gym equipment before and after use.

After the consent form was signed, the participants were required to complete the Physical Activity Readiness Questionnaire for Everyone (PAR-Q, Appendix A). The PAR-Q is a questionnaire that consisted of eight binary questions that assessed if the participants health may be at risk during the procedures of this study (Warburton et al., 2011). A participant would have been excluded from the study if they did not pass the PAR-Q, evident by checking the 'yes' box next to one or more questions (with the exception of the question that asks if test procedures were explained). A participant would have also been excluded if they reported a medical condition that prohibited them from performing weighted compound movements. In addition, a participant would have been excluded if they scored above an average of 75% across baseline trials. Although no participant was excluded from this study for health related reasons, one participant (Jane) was excluded from this study for scoring an average of 80.3% across three trials in baseline.

This study took place at two local gyms. Both gyms contained multiple squat racks and various other gym equipment (e.g., dead lift platforms, cable towers, and other free weights). One of the gyms was equipped with three automated external defibrillators and several gym staff members who were certified in first aid and CPR. The second gym was equipped with one automated external defibrillator. The gym was open with restricted access for 24-hr a day, 7 days a week and therefore, gym staff were not always present during the time of session. However, the primary researcher was certified in first aid and CPR and was present for each session.

Materials

A tablet and a smart phone that had a built-in video recording mode were used to record each participant perform the barbell squat at two angles that best showed the view of all steps in the task analysis (see Appendix B). Both devices were used to provide video feedback and to show the participant a video model. Both recording devices were capable of functions such as play, pause, fast forward, and rewind. A laptop was used during some sessions for two participants to record the primary researcher implement procedures with the participants so that a secondary observer could record procedural fidelity.

Squat racks were equipped with cast-iron or rubber coated weight plates that weighed 2.5, 5, 10, 25, and 45 lb. A 45 lb cast-iron barbell that was approximately 84 in. in length and 2 in. in diameter was held on the squat rack with two J-hooks. For John, two weight collars were used to secure cast-iron plates onto the barbell to prevent plates from moving during performance. Additionally, squat racks were retrofitted with removable safety rails along the bottom of the rack that the barbell may be released on. Safety rails ensured that the barbell may be dropped safely at any time during a squat without risk of injury to the participant or damage to the equipment.

Target Behavior and Data Collection

The primary dependent variable of this study was the barbell squat. A barbell squat is defined by three main components: standing, squatted, and return to standing. To start, an individual begins in a standing position with a barbell placed cross the trapezoids, then descending downward into a seated position until thighs are parallel to the floor. After, the individual returns back to a standing position. These three components are broken down into

smaller components on a task analysis. The task analysis in Appendix B defines each step of the barbell squat. The task analysis was validated by a certified personal trainer.

The participants were video recorded performing the barbell squat during baseline and intervention phases. Participants were scored using a 22-step task analysis. A (1) on the data collection sheet indicated that the participant completed a step correctly and a (0) indicated that the participant performed a step incorrectly. The percentage of correct steps was determined by dividing the number of correct steps by the total number of steps and multiplied by 100.

Interobserver Agreement

Secondary observers scored the participants barbell squat that was video recorded using the 22-step task analysis independent of the primary scorer across baseline, VF, and VF and VM conditions. Average scores for interobserver agreement are displayed in Table 1. For John, an average of 55.5% of trials were collected across baseline and VF conditions (100% and 46.6% respectively). For Kate, an average of 65.7% of trials were scored across baseline, VF, and VF with VM conditions (100%, 58.3%, and 38.9% respectively). Scorers marked (1) if a step is completed correctly and (0) if a step was completed incorrectly. Scorers were trained using behavioral skills training composed of instructions, modeling, rehearsal, and feedback to ensure scoring was completed without error (Himle et al. 2004). Scorers were re-trained if errors were detected. One scorer was re-trained.

Agreement was calculated between observers by dividing the number of steps agreed on by the total number of steps on the task analysis and multiplying by 100 to compute a percentage (Cooper et al., 2007). An agreement occurred if both observers scored a step as (1) or if both observers scored a step as a (0). The mean percentage of agreement for John was 86.4% across baseline and VF phases (81.8% and 88.3% respectively). The mean percentage of agreement for

Kate was 88.5% across baseline, VF, and VF with VM phases (94.7%, 83.1%, and 87.7% respectively).

Procedural Fidelity

An independent observer collected data on the researcher's implementation of procedures (see Appendix C, Appendix D, and Appendix E). Data were collected using a check-list. A (1) on the checklist indicated that the researcher executed a step correctly and a (0) indicated that the researcher performed a step incorrectly. Fidelity scores were calculated by dividing the number of steps the researcher performed correctly by the number of steps, then multiplying by 100. For Kate, procedural fidelity was collected for an average of 61.6% of sessions across baseline, VF, and VF with VM phases (100%, 50%, and 33.3% respectively). Procedures were implemented with 100% fidelity across phases. Procedural fidelity was not collected for John due to technology issues and COVID-19 restrictions.

Experimental Design and Procedures

A non-concurrent multiple-baseline across participants design with a sequence of baseline, VF, and VF and VM was used.

Submaximal One-repetition Maximum

Traditionally, one-repetition maximum (1-RM) is identified by gradually adding on more weight and performing repetitions until the individual can no longer lift the weight without assistance or without dropping the weight (Rogers, 2019). This may be strenuous on the body which can pose safety risks for individuals who have little weightlifting experience or live sedentarily. Submaximal 1-RM identifies a weight an individual can lift without requiring maximum exertion and potential strain on the body (Jimenez, 2018). This study recruited

individuals who had minimal or no weightlifting experience. Therefore, a submaximal weight equation was used to calculate a safe amount of weight for the participants to lift.

The equation used in this study to calculate submaximal weight was described by Brzycki (1993). The number of repetitions (*r*) a trainee can perform is divided by 30 and then added to one. The sum is multiplied by the weight (*w*) lifted by the trainee when performing repetitions to obtain a submaximal weight.

$$1\ \text{RM} = w\left(1 + \frac{r}{30}\right)$$

The participants were asked to choose a weight that they were comfortable lifting. If this was not known the weight of the barbell was used. Before repetitions began, the participants were told to release the barbell onto the safety rails if needed. Additionally, at least one member of the research team stood behind each participant to serve as a spotter. The participants were asked to perform as many repetitions as they were able to do to the best of their ability. Values *r* and *w* were then substituted into the equation and solved for 1-RM to obtain a submaximal weight that was used to perform the barbell squat. If submaximal 1-RM could not be reflected using 2.5, 5, 10, 25, or 45 lb plates in addition to the weight of the barbell (e.g., 71 lb), weight was rounded down to the nearest whole number that could be reflected (e.g., 70 lb).

John selected 55 lb (*w*) and completed nine repetitions (*r*). The weight John selected was composed of the weight of the barbell (i.e., 45 lb) with two 5 lb plates, one on each side of the barbell. John's submaximal 1-RM calculated to 71.5 lb but was rounded to 70 lb. This included the weight of the barbell, two 10 lb plates, and two 2.5 lb plates. One 10 lb and one 2.5 lb plate

were on each side of the barbell. Kate used the weight of the barbell (i.e., 45 lb; *w*) and completed two repetitions (*r*). No weight plates were used. Kate's submaximal 1-RM calculated to 48 lb but was rounded to 45 lb. The participants were not videotaped, and form was not assessed when determining submaximal 1-RM.

Warm-up

The participants were given an opportunity to warm-up with their preferred ritual for 10 min prior to each session. The warm-up portion was not video recorded and gave the participants an opportunity to stretch or complete a preferred active warm-up prior to lifting weight. John chose to stretch for warm-ups and Kate alternated between cardiovascular equipment (e.g., treadmill and stair stepper). The purpose of a warm-up period was to reduce potential risk of injury during baseline and intervention phases.

Baseline

The participants were asked to perform one repetition of the barbell squat that was video recorded using a tablet and smart phone. One device recorded the participants at a diagonal angle, while the other device simultaneously recorded at a back facing angle. The participants were allotted up to a 1-min break between repetitions. One repetition of the barbell squat was indicated as one trial. No feedback was provided for performance. One participant moved to the first intervention phase when data were stable or decreasing for three consecutive trials. Intervention was staggered across the remaining participant.

Video Feedback

The participants were asked to perform one repetition of the barbell squat that was video recorded using the same devices and recording angles as described above. After the barbell squat was completed, the participants were immediately shown their video recording taken at the

diagonal angle. The back facing video was shown during feedback when it better displayed specific steps on the task analysis. For example, the back facing angle better displayed width of hand placement on the barbell (step 3) and width of feet (step 7) relative to the diagonal angle. The primary researcher used video features such as play, pause, rewind, fast forward, and slow motion while providing VF. The video recordings were paused at least three times but more when needed to deliver descriptive praise (e.g., "Nice work ducking under the barbell") for each step that was completed correctly and corrective feedback (e.g., "Next time try placing your hands wider than the width of your shoulders") for each step that was completed incorrectly. This process was repeated two times so that each session had three repetitions of VF. After VF, the participants were asked to perform the barbell squat three times without VF for assessment purposes. Participants were given up to 1-min of rest between assessment repetitions. If a participant scored 100% in the VF phase, they would not move into the next treatment phase. This applied to one participant (John).

Video Feedback and Video Modeling

Before the participant (Kate only) performed one repetition of the barbell squat, two videos were shown displaying an experienced model performing the barbell squat using the same recording angels that were described in the baseline and the VF conditions. The experienced model was the same sex as the participant who received VF with VM (Kate). The participant was allowed to view both video recording angles for up to 1-min. Next, the participant was video recorded performing a barbell squat. When the participant completed the barbell squat, VF was implemented as described above. This process was repeated two times so that each session had three repetitions of VF and VM. After VF and VM, the participant performed the barbell squat

three times without VF and VM for assessment purposes. The participant was given up to 1-min of rest between assessment repetitions.

Social Validity

Preference and personal benefits of the interventions were assessed using a 5-point Likert scale that was similar to Mulqueen (in press; see Appendix F). A questionnaire containing four to six statements regarding VF and VF with VM were presented to John and Kate. John was asked not to respond to questions regarding VF with VM (i.e., questions five and six). Questionnaires were presented via an online survey platform. The scales displayed the following response anchors for each statement: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The purpose of the social validity questionnaires was to assess the feasibility and acceptability of the intervention.

Additionally, social validity was recorded with certified personal trainers who rated the participants performance of the barbell squat from each phase (Appendix G). At the end of the study, two certified personal trainers viewed three video recordings that were obtained from baseline, VF, and VF and VM phases in arbitrary order. Only the diagonal angle of each barbell squat was shown to personal trainers. The personal trainers rated how well the participants performed the barbell squat in each phase using a 10-point scale from executed poorly to (1) to perfectly (10). The video recordings were rated independently, and the treatment phase was unknown to the personal trainers. Only one personal trainer rated videos from each phase for John due to time constraints.

Table 1. *Average Interobserver Agreement Scores*

	Trials Scored Across Conditions (Avg.)	**Level of Agreement (Avg.)**
John	55.5% (100%, 46.6%)*	86.4% (81.8% and 88.3%)*
Kate	65.7% (100%, 58.3%, 38.9%)**	88.5% (94.7%, 83.1%, 87.7%)**

* Across baseline and VF phases respectively
** Across baseline, VF, and VF with VM phases respectively

Average trials scored for interobserver agreement across baseline and intervention phases for both participants are shown in column two. Average agreement between scorers across baseline and intervention phases are displayed in the last column.

CHAPTER THREE:

RESULTS

Results, shown in Figure 1, display the percentage of correct steps scored on the task analysis for barbell squats for John and Kate during assessment trials for baseline, VF, and VF with VM (Kate) phases. Average scores of barbell squats are displayed in Table 2. The average from the entire baseline and intervention phases are reported for John and Kate. Additionally, averages from the end of each phase are reported for both participants to show the highest level of improvement. John improved his performance from a mean of 68.2% in baseline to a mean of 97.5% in the last six assessments in the VF phase. The VF with VM phase was not implemented with John. Kate improved her performance from a mean of 55.3% in baseline to a mean of 77.3% in VF (although her last three data points were 81.8% on average). In VF and VM, Kate scored an average of 82.5% (although her last three data points were 86.4% on average).

John and Kate completed the social validity questionnaire at the end of the study. Average ratings are shown in Table 3. Kate rated highly across questions. Although indicated a low rating for enjoyment of the study, high ratings were delivered for questions regarding overall results, usefulness, and future use. Mean ratings for John and Kate were 4.25 and 5 respectively. Overall, ratings indicated that both participants found VF and VF with VM (for Kate) useful and liked the results they achieved.

Social validity ratings from personal trainers are shown in Table 4. Ratings were collected across each phase for John and Kate. Only one personal trainer rated John's baseline video due to time constraints. Ratings from personal trainers did not indicate significant

differentiation in barbell form between videos from each phase (differences ranging from 1-2.5 points). Average ratings for John and Kate's baseline videos were 7 and 6.5 respectively. Average ratings for John and Kate's VF videos were 6 and 4 respectively. The average rating for Kate's video in the VF with VM phase was 5.5

Tables and Figures

Table 2. *Average Scores for Barbell Squats*

	BL (Avg.)	**VF (Avg.)**	**VF with VM (Avg.)**
John	68.2%	88.8% 97.5%*	—
Kate	55.3%	77.3% 81.8%**	82.5% 86.4%**

*Last six assessment trials
**Last three assessment trials

Percentage of steps correct on average are based on the task analysis. Scores are shown on across baseline and intervention conditions for both participants. An * indicates score on average across last six assessment trials (John). An ** indicates score on average across last three assessment trials (Kate).

Table 3. *Social Validity for Participants*

	I enjoyed participating in the study	I am happy with the overall results I achieved	Video feedback was helpful in improving my barbell squat form	I would like to use video feedback more often when practicing weightlifting movements	Video feedback with video modeling were helpful in improving my barbell squat form	I would like to use video feedback with video modeling more often when practicing weightlifting movements	**Mean Rating**
John	2	5	5	5	-	-	4.25
Kate	5	5	5	5	5	5	5

The top row displays social validity questions that participants were asked and corresponding ratings from both participants in the subsequent rows. The last two questions in regard to VF with VM did not apply to John. The last column displays mean rating across social validity questions.

Table 4. *Social Validity for Personal Trainers*

	John BL	**Kate BL**	**John VF**	**Kate VF**	**Kate VF with VM**
Personal Trainer 1	-	6	-	5	6
Personal Trainer 2	7	7	6	3	5
Mean Rating	7	6.5	6	4	5.5

Personal trainers rated how correct barbell squat form appeared in one video (displaying the diagonal angle) from each phase for both participants. Only one personal trainer rated John's baseline video. Personal trainers were blind to the conditions of the videos they rated.

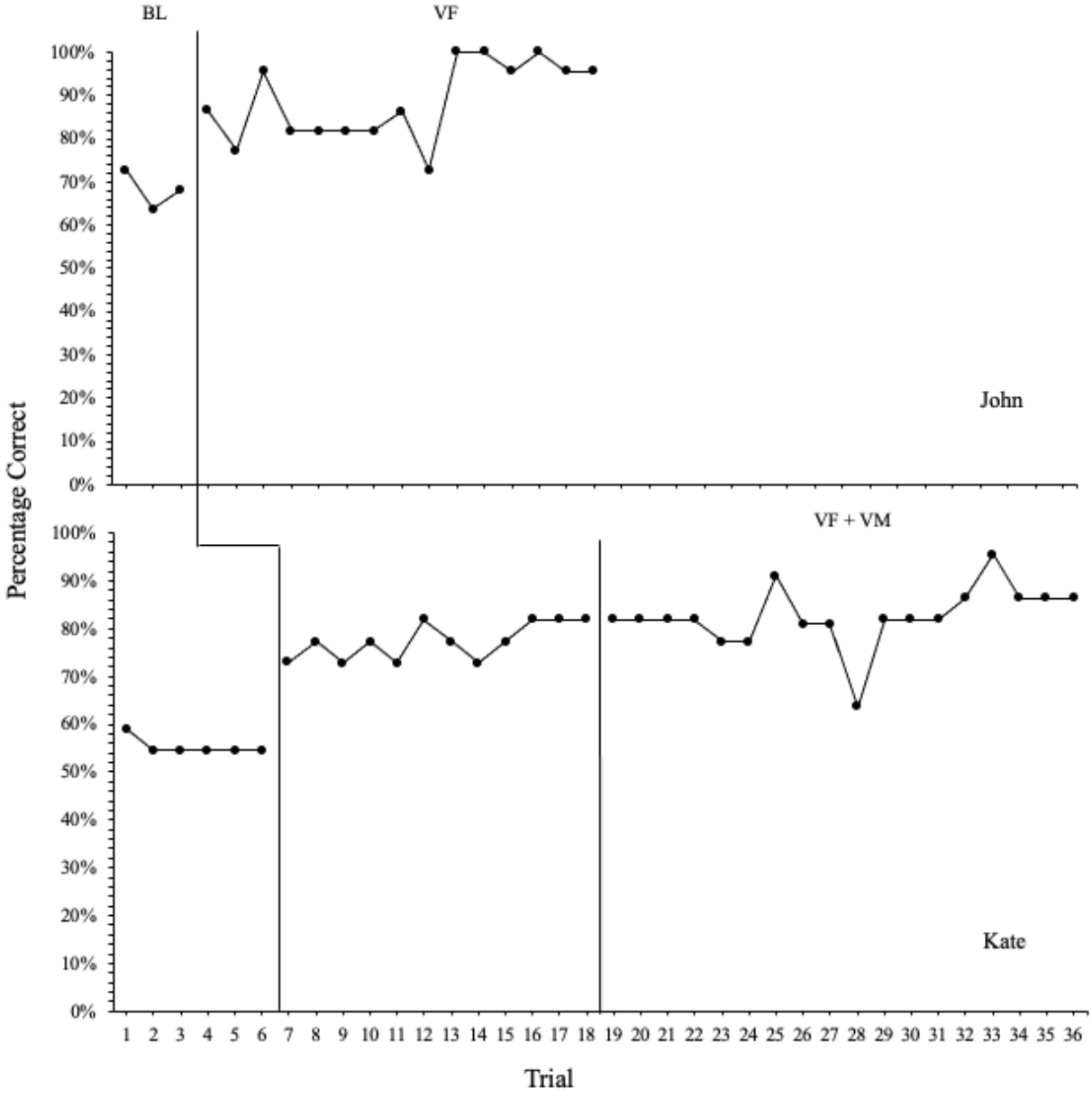

Figure 1. *Percentage of steps correct for barbell squats for John and Kate across baseline and intervention phases*

CHAPTER FOUR:

DISCUSSION

This study evaluated the effects of VF on improving barbell squat form. Additionally, VF and VM were evaluated for one participant (Kate) to examine if the addition of VM produced further increases in performance. For both participants, VF produced an immediate increase in barbell squat form relative to performance in baseline. In the VF phase, John reached 100% of steps correct on the task analysis for some trials towards the end of the VF phase. Thus, John did not move into the VF and VM phase. Although Kate did not reach 100% in VF, her barbell squat form increased 27% from baseline to the end of the VF phase. These results demonstrate that VF is effective at improving barbell squat form for typically developing adults who are novices to weightlifting.

For Kate, VF and VM did not substantially increase barbell squat form relative to performance in the VF phase (a 4.6% increase). Slight increases in level are demonstrated towards the end of the VF and VM phase (i.e., last three points) relative to the end of the VF phase. Kate did not reach 100% at any point during this study. Kate was not able to push her hips backwards until her thighs were parallel to the floor when descending into a squatted position (step 11 on the task analysis) at any point during the study. This is likely due to Kate not having the range of motion to descend to this depth. Additionally, Kate achieved specific steps on the task analysis only rarely during both intervention phases. These steps included keeping feet flat on the floor (step 12) and aligning knees with toes (step 13) when descending into a squatted position and pushing knees outward (step 20) when returning to a standing position. Although

Kate improved on these steps throughout the course of the study, she did not consistently emit them to meet the definition. Often times Kate's left side of her body met the definition, but her right side did not. Kate expressed to the researcher that she has more strength in her left leg relative to her right leg. Thus, Kate's level of improvement may have been impacted by physical limitations rather than a skill deficit.

This study extends the sports performance literature on VF (BenitezSantiago & Miltenberger, 2016; Kelley & Miltenberger, 2016). As demonstrated by Kelley and Miltenberger (2016) with horseback riding skills, VF produced immediate increases in level for both participants. Despite immediate increases, barbell squat performance on average (across trials) did not substantially increases for one of the participants. This is similar to results demonstrated by BenitezSantiago and Miltenberger (2016) that examined the effects of VF on martial art movements. Kelley and Miltenberger (2016) described benefits of providing VF immediately after performance. Although VF was delivered immediately after participants performed the barbell squat in both phases, it is unknown if this contributed to performance.

In addition, this study adds to the limited research conducted on weightlifting. Mulqueen et al. (in press) evaluated VF and VM on two weightlifting movements (i.e., the clean and jerk and the snatch) and showed large improvements. This study showed that substantial improvements could be gained with VF alone and that VF with VM did not produce further significant increases in barbell squat form for Kate. This study is novel in the sense that VF alone has not been examined with weightlifting movements to the authors knowledge. Furthermore, this is the first study to examine VF with the added benefit of VM subsequent to VF alone in the sports performance literature. Lastly, no study to the authors knowledge has targeted the barbell

squat. Other studies have targeted weightlifting movements such as the snatch, clean and jerk (Mulqueen et al., in press), split squat, punch-out squat, and shoulder press (Carter et al., 2017).

Despite contributions of this study, there are a few limitations that should be noted. First, follow-up data were not collected due to time constraints. Future research should examine if barbell squat performance maintains after VF and VF with VM. A second limitation was the inability to account for small improvements in form observed for specific steps on the task analysis during intervention phases (Kate specifically). Additional research should consider a data collection system that accounts for minor improvements that do not necessarily meet criteria. Minor improvements towards criteria may be worth indicating for participants with limited range of motion or strength disproportions and may function as reinforcement. A third limitation is the number of participants recruited for the study. Barriers to recruitment were gym closures due to the COVID-19 Pandemic and the distance of one gym. Thus, this study should be replicated with more participants in the future to establish experimental control. Additionally, it was not always feasible to have an additional member of the research team on sight to collect treatment integrity across phases. This was due to strict gym entry restrictions (i.e., non-members not allowed) in place during the COVID-19 Pandemic. Video-recorded sessions were used when possible in attempt to gather treatment integrity; However, technology issues (e.g., not able to hear audio for all steps) were present and treatment integrity could not be scored for John. Additionally, some steps may have been difficult to score depending on the clothing or shoes the participant wore to session. For example, if may have been difficult to see correct barbell placement if participants wore baggy hooded sweatshirts. In the future, researchers may consider requesting that participants refrain from wearing baggy clothing or shoes with thick soles.

Lastly, limitations for the social validity ratings that were obtained from personal trainers should be noted. Ratings from personal trainers did not differ significantly from each phase for both participants (difference ranging from 1-2.5 points). Personal trainers were only shown one angle (i.e., diagonal angle) for each barbell squat across participants due to long video loading times. One personal trainer expressed that it was difficult to see crucial form components such as knees caving inward and angle of the toes from this angle alone. Personal trainers were asked to rate the video to the best of their abilities despite visual restriction. Thus, personal trainers may not have been able to see small components of correct barbell squat form that were listed on the task analysis from the video angle that was shown. Despite the researcher telling both personal trainers that the video were not presented in a particular order, it is possible that personal trainers expected subsequent videos to improve. Future research should ensure multiple angles of barbell squats are shown to personal trainers to gather more accurate ratings.

Overall, this study demonstrated that VF is effective at promoting immediate increases in barbell squat form with novice level adults that are typically developing. Increases in correct barbell squat form was substantial for one participant (John) and more modest for the second participant (Kate). Additionally, the results of this study also demonstrated that VF and VM did not produce substantial increases in performance for one participant (Kate). Future direction in this area should continue examining the effects of VF and VF with VM on barbell squat form and other weightlifting movements to expand the literature on weightlifting performance.

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APPENDICES

Appendix A: Physical Readiness Questionnaire for Everyone (PAR-Q)

PRE-TEST QUESTIONNAIRE

NAME …….

Date of Birth …… Age: …….

Test procedure ……..

Please tick appropriate box

	YES	**NO**
Has the test procedure been fully explained to you?	□	□

Any information contained herein will be treated as confidential

1.	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?	□	□
2.	Do you feel pain in your chest when you do physical activity?	□	□
3.	In the past month, have you had chest pain when you were not doing physical activity?	□	□
4.	Do you lose your balance because of dizziness or do you ever lose consciousness?	□	□
5.	Do you have a bone or joint problem that could be made worse by a change in your physical activity?	□	□

6.	Is your doctor currently prescribing drugs for your blood pressure or heart condition?	□	□
7.	Do you know of any other reasons why you should not undergo physical activity? This might include severe asthma, diabetes, a recent sports injury, or serious illness.	□	□
8.	Have you any blood disorders or infectious diseases that may prevent you from providing blood for experimental procedures?	□	□

- If you have answered **NO** to <u>all</u> questions, then you can be reasonably sure that you can take part in the physical activity requirement of the test procedure

I ……. declare that the above information is correct at the time of completing this questionnaire Date ……/……/…….

Please Note: If your health changes so that you can then answer YES to any of the above questions, tell the experimenter/laboratory supervisor. Consult with your doctor regarding the level of physical activity you can conduct.

- If you have answered **YES** to one or more questions:
  Talk with your doctor in person discussing with him/her those questions you answered yes. Ask your doctor if you are able to conduct the physical activity requirements.

Signature of Experimenter……. Date ……/……/…….

Appendix B: Task Analysis/Data Collection Sheet for Barbell Squat

Participant (initials): _____ Phase: _____ Trial: _____ **Scoring: 0= Incorrect 1= Correct**
Submaximal weight (lb): _____ Data collector: _____

Step	Component	Description	0 or 1
1	Standing	Double overhand grip (i.e., fingers wrapped around the barbell)	
2		Duck under barbell	
3		Hand placement is wider than shoulder width apart	
4		Barbell is rested below the neck and on top of the trapezoids	
5		Pinch shoulder blades back	
6		Take at least two small steps backwards	
7		Feet are shoulder width apart	
8		Toes are pointed slightly outwards	
9		Knees are straight	
10		Back is straight	
11	Squatted	Push the hips backwards into a seated position until thighs parallel to the floor	
12		Feet are flat on the floor	
13		Knees are aligned with the toes (i.e., kneecaps do not surpass toes and do not caving inward)	
14		Back remains straight while in seated position	
15		Chest is up	
16	Return to standing	Extend both legs upward	
17		Push hips forward	
18		Back remains straight	
19		Chest remains up	
20		Knees are pushed outwards and aligned with toes	
21		Stop when standing	
22		Rest barbell on squat rack	

Appendix C: Procedural Fidelity Data Collection Sheet for Baseline

Step	Circle yes, no, or N/A	Comments
1. Researcher asks participant to perform the barbell squat	Yes / No / N/A	
2. Records the participant performing the barbell squat	Yes / No / N/A	
3. Gives the participant up to 1-min to rest in between repetitions	Yes / No / N/A	

Appendix D: Procedural Fidelity Checklist for Video Feedback

VF Procedural Fidelity
1. Recorded the participant perform the barbell squat
2. Allowed the participant to take up to a 1-min rest
3. Showed the participant their video recording
4. Pause video after standing component
5. Delivered praise or corrective feedback for step 1
6. Delivered praise or corrective feedback for step 2
7. Delivered praise or corrective feedback for step 3
8. Delivered praise or corrective feedback for step 4
9. Delivered praise or corrective feedback for step 5
10. Delivered praise or corrective feedback for step 6
11. Delivered praise or corrective feedback for step 7
12. Delivered praise or corrective feedback for step 8
13. Delivered praise or corrective feedback for step 9
14. Delivered praise or corrective feedback for step 10
15. Resumed the video
16. Paused the video after the squatted component
17. Delivered praise or corrective feedback for step 11
18. Delivered praise or corrective feedback for step 12
19. Delivered praise or corrective feedback for step 13
20. Delivered praise or corrective feedback for step 14
21. Delivered praise or corrective feedback for step 15
22. At end of video delivered praise or corrective feedback for step 16
23. Delivered praise or corrective feedback for step 17
24. Delivered praise or corrective feedback for step 18
25. Delivered praise or corrective feedback for step 19
26. Delivered praise or corrective feedback for step 20
27. Delivered praise or corrective feedback for step 21
28. Delivered praise or corrective feedback for step 22

Appendix E: Procedural Fidelity Checklist for Video Feedback and Video Modeling

VF with VM Procedural Fidelity
1. Show participant recording of model
2. Allow participant to view model for up to 1-min
3. Recorded the participant perform the barbell squat
4. Allowed the participant to take up to a 1-min rest
5. Showed the participant their video recording
6. Pause video after standing component
7. Delivered praise or corrective feedback for step 1
8. Delivered praise or corrective feedback for step 2
9. Delivered praise or corrective feedback for step 3
10. Delivered praise or corrective feedback for step 4
11. Delivered praise or corrective feedback for step 5
12. Delivered praise or corrective feedback for step 6
13. Delivered praise or corrective feedback for step 7
14. Delivered praise or corrective feedback for step 8
15. Delivered praise or corrective feedback for step 9
16. Delivered praise or corrective feedback for step 10
17. Resumed the video
18. Paused the video after the squatted component
19. Delivered praise or corrective feedback for step 11
20. Delivered praise or corrective feedback for step 12
21. Delivered praise or corrective feedback for step 13
22. Delivered praise or corrective feedback for step 14
23. Delivered praise or corrective feedback for step 15
24. At end of video delivered praise or corrective feedback for step 16
25. Delivered praise or corrective feedback for step 17
26. Delivered praise or corrective feedback for step 18
27. Delivered praise or corrective feedback for step 19
28. Delivered praise or corrective feedback for step 20
29. Delivered praise or corrective feedback for step 21
30. Delivered praise or corrective feedback for step 22

Appendix F: Social Validity Questionnaire for Participants

Participant (Initials): _____ Date: _____				
1. I enjoyed participating in the study				
1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
2. I am happy with the overall results I achieved				
1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
3. Video feedback was helpful in improving my barbell squat form				
1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
4. I would like to use video feedback more often when practicing weightlifting movements				
1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
5. Video feedback with video modeling were helpful in improving my barbell squat form				
1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
6. I would like to use video feedback with video modeling more often when practicing weightlifting movements				
1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Appendix G: Social Validity Questionnaire for Personal Trainers

Trainer (initials): _____ Date: _____

Video 1	Comments
The barbell squat was performed: Very poorly Perfectly 1 2 3 4 5 6 7 8 9 10	
Video 2	
The barbell squat was performed: Very poorly Perfectly 1 2 3 4 5 6 7 8 9 10	
Video 3	
The barbell squat was performed: Very poorly Perfectly 1 2 3 4 5 6 7 8 9 10	

Appendix H: IRB Approval Letter

UNIVERSITY of SOUTH FLORIDA

APPROVAL

August 19, 2020 * This letter supersedes the previous letter dated August 18, 2020

Alexandra Olles
14059 Riveredge Drive APT ~~602~~ 6204
Tampa, FL 33637

Dear Alexandra Olles:

On 8/17/2020, the IRB reviewed and approved the following protocol:

Application Type:	Initial Study
IRB ID:	STUDY001335
Review Type:	Expedited 6, 7
Title:	Video Feedback with and without Video Modeling to Enhance Barbell Squat Form
Funding:	None
IND, IDE, or HDE:	None
Approved Protocol and Consent(s)/Assent(s):	• Video Feedback with and without Video Modeling to Enhance Barbell Squat Form; • Adult Consent Form; Approved study documents can be found under the 'Documents' tab in the main study workspace. Use the stamped consent found under the 'Last Finalized' column under the 'Documents' tab.

Within 30 days of the anniversary date of study approval, confirm your research is ongoing by clicking Confirm Ongoing Research in BullsIRB, or if your research is complete, submit a study closure request in BullsIRB by clicking Create Modification/CR.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

Jennifer Walker
IRB Research Compliance Administrator

Institutional Review Boards / Research Integrity & Compliance
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