The Effect of Body Indexing on Improvement on Volleyball Serving Accuracy vs. Conventional Methods

Zachary Rodgers

April 14, 2018

1 Abstract

Volleyball is a fast-paced sport that is quickly growing in popularity. Every point in volleyball begins with a serve. An experiment was done to see if there is a way to improve traditional coaching techniques in order to help more people learn quickly how to serve accurately. The experiment consisted of subjects serving four rounds of ten serves at a target to test accuracy. Feedback from a coach was given between rounds in conjunction with video playback of the subject serving. Each serve was given a score from zero to ten based on how close to the center of the target the serve landed. Each round score was then created by computing the sum of all scores from that round. A percent growth calculation was then used to measure growth after receiving feedback. Each server received both types of video playback, the traditional color video or body indexing: a process of creating an animated model of the limbs and joints that connect them. A matched pairs test was run on the differences between servers growth from each type of playback. The analysis concluded that neither form of playback was statistically superior to the other.

2 Introduction

Volleyball is one of the fastest growing youth sports in the country. One of the most important skills to develop of any person wanting to be considered a well rounded player in the game is the serve. Serving accurately is an essential skill for the player to have to compete at the higher levels of the game. One way that players improve their accuracy is by receiving feedback on their technique from a coach while using video playback from a video camera. This experiment tests to see if through the feedback from a certified volleyball coach and using video collected by Motion Capturing Software through the Microsoft Kinect, a player who views their technique using body indexing in their video playback can improve their standing float serve accuracy a statistically significant amount as

opposed to using traditional color playback. The experiment taking place will be building off a conclusion drawn from an experiment in 2002 about using video playback in learning volleyball skills and will test what is the better form of playback in conjunction with instruction from a certified volleyball coach in order to better improve the volleyball player's serving accuracy.

3 Background

Serving in volleyball is one of, if not the most important skill a player can have. Every point begins with a serve, not being able to accurately serve can lead to your team being at a disadvantage trying to gain points by allowing an easier to defend play, or allowing the other team to score by missing your serve altogether. Serving is so important to volleyball that until the mid 2000's a team could only be awarded points if they were serving to begin the rally; if the team receiving the serve won the rally, they were only awarded the opportunity to serve.

In regards to designing the experiment two decisions needed to be made: the serve style to be used and how the camera will be recording. There have been related works in both of these decisions which aided in giving the experiment structure. Most of the research done on the camera and how it records video data was done in the late 2000's and can be considered to be the most up to date. With the information of this background research, a clearer picture of how to run the experiment and create the software becomes apparent.

3.1 Selection of Serve Style and Camera Placement

Whenever learning a new physical or athletic skill two things must always be in mind: the difficulty of the skill to perform and the toll the movement takes on the body. In our study the standing overhead serve will be used as our general skill to be learned because the attack (spike) skill has too many uncontrollable elements such as: timing, player's jumping ability, distance from the net at time of attack, height of the ball at time of attack, among many others. The overhead version of the serve was selected as opposed to its underhand counterpart due to the use of the overhead serve in competitive play; the underhand serve is notoriously easy to defend and has all but been eliminated from competitive play. In 2010 Reeser published a paper about the bio-mechanics of volleyball and what stresses and forces in regards to the shoulder joint occur throughout each of these movements. The paper concluded that the two serving techniques that put the least amount of stress on the player's shoulder are the standing roll shot serve, and the standing float serve [Reeser et al., 2010]. The standing roll shot serve is an advanced serve that has very difficult technique to master as it a topspin-style serve that heavily relies on height of player, timing, height of contact with the ball, location of the toss, player's shoulder strength, and speed of a snap of the wrist. The standing float serve however has little to no spin, and relies only on location of where the ball is in the ventral portion of the

coronal plane of body[1] and the point of contact on the ball. This supports the decision of using the standing float serve as the skill to be learned throughout this experiment. Using the float serve will lead us to the most consistent results in testing the accuracy for our servers as there are less variables to control.

The best way to capture this motion is through the Microsoft Kinect camera acting as a single capture point due to its ability to track motion and reconstruct it digitally. In 2010 Duarte released an article about tracking complex movements with only one camera. Results found that having the camera face the subject parallel to the subjects point-of-view is the best way to capture the motion for the reconstruction process [Duarte et al., 2010]. This justifies placing the capturing system in front of the server to capture the entire movement. By using real time capturing, accurate models can be rendered using the data from the camera to be used in playback [Warade et al., 2012]. The feedback portion of this study will use this information to create a video playback of the subject serving in whichever playback style is being used in the current round. Real-time Capturing is needed for this to be done properly as predictive capturing algorithms and gestures would not be able to adequately give the feedback to create the models required.

3.2 The Zetou Study

The term body indexing is the collection of the location of twenty-six joints and the animation of what resembles a stick figure rendered on screen displaying the motions captured through the camera. This feedback could be more effective because the rendering of the figure would be simpler to understand for the server due to lack of outside stimuli and the server can only see their specific joint movements. In 2002 Zetou et. al published a paper about using modeling for learning specific volleyball skills. They found that the subject watching themselves in standard color playback is not the most effective way to learn a new technique [Zetou et al., 2002]. This study is an extension of Zetou's, building off of this conclusion by testing if body indexing is more effective than traditional color playback if both forms of playback are used in conjunction with instruction and feedback from an IMPACT[2] certified United States Association of Volleyball Coach.

This study is useful in giving a foundation for this research. Zetou found that while playback of the subjects is not the ideal way to learn a new volleyball skill there was growth in the technique of the subjects who used it. This experiment builds on this premise by testing if there is a way to show the subject their technique and how to improve it in a more effective fashion than traditional color video playback of the subject and a coach pointing out what to do properly. The inclusion of body indexing breaks down the video to a joint-and-limb level and eliminates other stimuli from the video playback.

[1] The ventral portion of the coronal plane is the front half of the body when dividing on a plane parallel to the shoulders

[2] IMPACT certification is a requirement to coach at any level in the United States or Internationally

4 Methodology

The individual contribution to the software is through the combining of online tutorials to be able to switch the video being shown from body indexing joint data to traditional color playback. The creation of a user interface that is able to seamlessly switch from these two is also needed to be created to properly display the video data.

This experiment serves the purpose of testing if body index data being played for the server in conjunction with coach's instruction has a higher growth of serving accuracy than traditional color playback. The server selects from where they will serve from, in order to best represent an in-game situation. The recreation of an in-game situation is necessary to test the validity of using this experiment's results for improving a player's skills at a competitive level. The court used is a regulation volleyball court (two 30'x30' squares divided by a net, the top of the net will be at a height of 7'4"). Each trial is represented in the data table by its corresponding server ID number. After the server's location has been selected the camera is placed in front of the server in order to capture the server's movement (As seen in Figure 1 below).

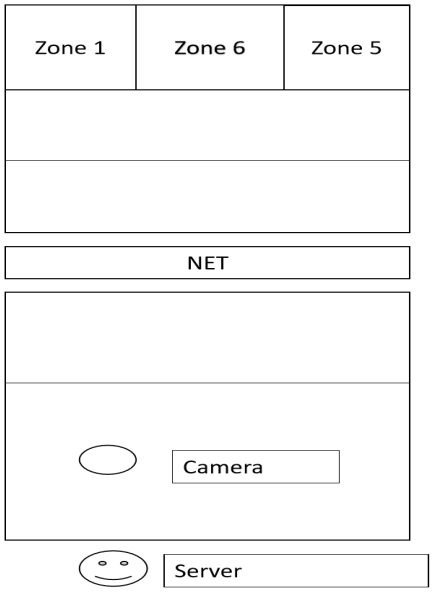

Figure 1: The Volleyball Court Setup

After placing the camera the target zone is selected randomly from one of the following zones (these can be found in Figure 1): zone 1 (deep left), zone 5 (deep right), the space between zone 1 and 6 (known hereafter as the 1-6 seam), and the space between zone 5 and 6 (known hereafter as the 5-6 seam), these are the zones selected due to their effectiveness in-game at obtaining aces, an

automatic point to the serving team, and being difficult to defend if the serve is not an ace. A target resembling a square bulls-eye is placed in the zone to be able to quantify the accuracy of the serves (As seen in Figure 2 below). After the target has been placed the server completes 10 standing float serves towards the target.

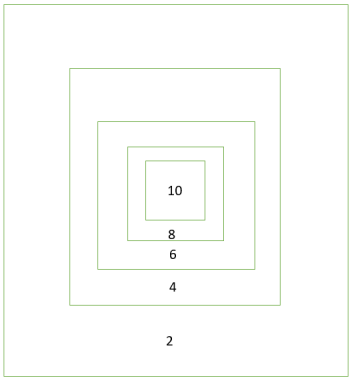

Figure 2: The Target

The far edge of the target is placed at the baseline of the court. If either zone one or zone five are selected the outside edge of the target is placed at the corresponding sideline. If one of the seams is selected then the target is placed with the center of the target on the border of each of the zones that make up the seam. The target at its widest has the dimensions of ten feet wide, ten feet long, and each scoring area inward will be one foot offset inwardly from the scoring area it is contained in, the scoring area worth the highest points has the dimensions of two feet wide by two feet long. The maximum score for a serve is ten points and if the target is missed all together the serve receives a score of zero. If a serve lands on the border of two scoring areas the score received will be the average of the scoring areas on each side of the border. These ten serves are summed together to form the score for the round. The maximum score for a round of serving is 100. After serving the server then goes to the monitor and receive feedback on their technique from the coach present while also being shown the appropriate video playback. The first playback style for odd number ID subjects is traditional color playback, for even number ID subjects body indexing is the first feedback given. This is done to ensure an equal number of trials are completed with each playback being the first given to the subject to eliminate bias due to muscle memory. If every subject had the same playback style first, they could have retained notes from feedback from a previous round that could skew results towards which feedback was given second, as they have had more practice serving by this round. After receiving feedback the server serves an additional ten serves at the target zone with their scores recorded. After resting for five minutes the server serves a new set of ten serves from the

same serving location to the same target zone. The server then comes to the monitor to receive their feedback from the other style of playback. Then the server serves a final set of 10 serves for their serves to be recorded. After the scores for this final set have been recorded a single trial of data collection has been completed.

The software that has been created uses Visual Studio 2013 and Kinect Studio in order to complete the experiment. The Software uses tools from the Kinect SDK v2.0 to connect to the camera and create the user interface to properly obtain the visual data obtained by the Kinect. The software combines different tutorials for the Kinect in order to collect all the data that is needed. The video of the serving will be recorded using Kinect Studio, then when playing the video the user interface will be a window made in Visual Studio 2013 that pairs with Kinect studio to be able to control the view between the forms of playback so that the proper form of feedback is selected. The user interface will also include a back button when playing video in case the improper form of playback is selected. The user interface model can be seen in Figure 3, Figure 4 below shows what playback looks like with color style playback, and Figure 5 shows what playback looks like when selecting body indexing.

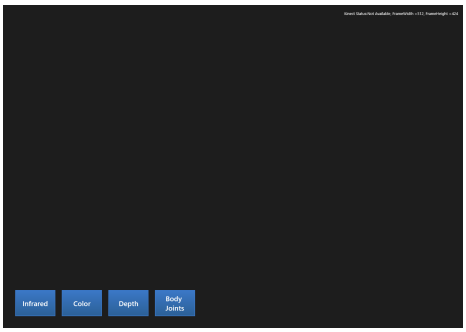

Figure 3: User Interface for the Software

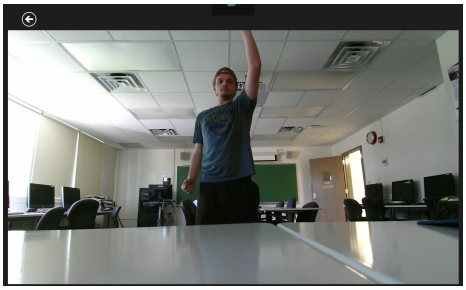

Figure 4: Example of UI using Color Playback

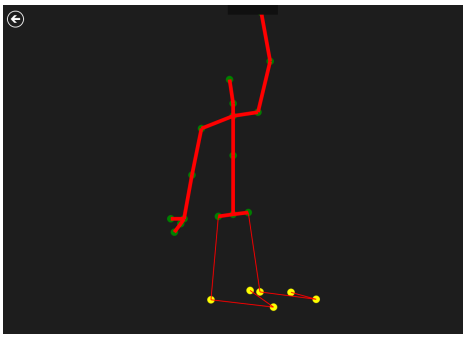

Figure 5: Example of UI using Body Playback

The subjects of the experiment were members of the general public with varying levels of volleyball experience in order to best recreate the circumstances of Zetou's experiment. We gathered thirty subjects in order to obtain enough data points to perform the proper analysis on the data to draw conclusions.

The data of the experiment collected was the score of each individual serve, the sum of scores for each round of 10 serves, and the percent growth of score from before and after receiving feedback. Percent Growth from round to round was used to quantify by how much the accuracy improved after looking at the playback. We hoped to see how much the Body Indexing playback helps improve serving accuracy by improving technique, and see on average if the growth of accuracy improves by a significant amount over typical color playback. A matched pairs analysis was used to do this by taking the difference between the percent growth due to body indexing playback and color playback. This software could prove to be effective in the improvement of volleyball serving ability in for anyone wanting to learn the game in the future.

5 Data and Results

Throughout the experiment there were 1200 individual serve scores recorded, each of these were given a score from zero (missing target completely) to ten (hitting the middle of the target). Each individual serve was a part of a set of ten serves which were summed together to give a round score. A percent growth computation was conducted to measure by how much the accuracy score grew after receiving feedback from the coach and viewing their playback of the previous round of serving. Each of these growth calculations had a corresponding match of the same server with their percent growth from receiving feedback with the other style of playback. The difference between these two calculations was computed in order to perform the proper analysis on this data. Table 1 shows us the average growth for each of our playback styles as well as the average difference between the two.

Table 1: Average Growth from Playback Style and Their Difference

BI Avg Growth (%)	Color Avg Growth (%)	Avg Difference (%)
53.27	58.94	-5.66

There were three separate analyses performed on this set of data in order to draw conclusions: a matched pair testing if body indexing playback was statistically significantly better, a matched pair testing if color playback was statistically significantly better, and a matched pair testing to see if there was a statistically significant difference between the two playback styles at all. These results can be seen above in Table 2.

Table 2: Results of matched pairs analysis

Test	T-Value	P-Value
Body Index > Color	-0.89	0.269
Color > Body Index	-0.89	0.731
Significant Difference	-0.89	0.537

Since we are testing on a 95% confidence level, to be considered a significant value our p-values must be less than 0.05. As we can see in Table 2 none of our tests gave us a significant value. This means that statistically there is no benefit of using body indexing for video playback for aiding a coach in showing what a server is doing wrong in order to improve technique, therefore accuracy. This analysis also means that color playback is not statistically better in performing this task as well. This explains the fact that there is not a statistically significant difference between our two means based on the data collected. Through the data collected no conclusion can be drawn whether one style of playback is statistically superior to the other in regards to increasing serving accuracy.

6 Conclusions and Discussion

The original hypothesis of this experiment cannot be supported by the data collected. The data did not show that body indexing is a superior method of video playback to be used with coach's instruction to improve serve accuracy. Conversely, the data also did not show that color playback was superior either. The data showed that there was not a statistical difference between the two styles of playback. Figure 6 below is a visual representation of what our two average growths of score in the experiment are; as confirmed in Table 1 the difference is very small, only a 5 point difference between the two forms of playback on average. Since the error bars overlap, we can conclude that their difference is not significant. As seen in the graph and Table 1, we can see that

color playback actually had a higher average percent growth after receiving feedback than when they received feedback with body indexing playback

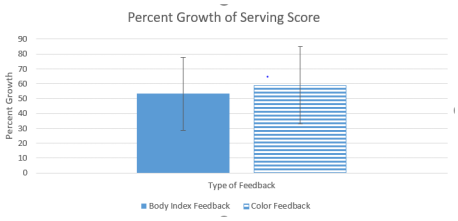

Figure 6: Graph of Average Growth Depending on Playback Style

When looking at Figure 7 below, we can see that the growth in score is high at when the starting score is lower, but there is a trend of the higher the starting score, the lower the growth in score between rounds when using color playback. When looking at Figure 8 we see that this trend does not exist when using body indexing playback. This could lead to a conclusion that body indexing could be more effective with experienced players, but that would have to be done in a separate study using only experienced players as subjects.

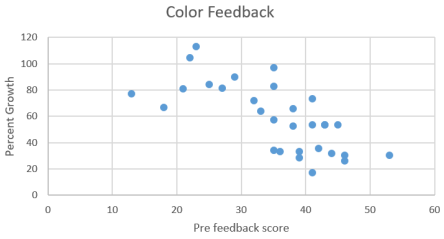

Figure 7: Scatter Plot of Color Data

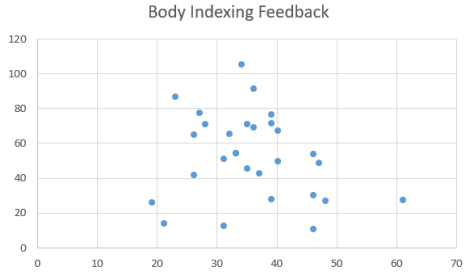

Figure 8: Scatter Plot of Body Index Data

Some limitations to this study was the varying level of skill of test

subjects. Some came in with volleyball experience so they already knew what the initial serving motion and how to modify it to hit the target. On the other hand some subjects had never played volleyball in their lives so they had no basis on how to initially perform the task. One way to improve this in future studies would be to play a short video of what is supposed to be done so less experienced subjects would understand what they needed to do to accomplish the task. Recreating an in-game situation also caused issues, in a full match there is a score, a crowd, pride, and various other situations that affect a player mentally that cannot be recreated in an isolated experiment setting.

Another limitation of the study was the space and resources required in order to conduct testing. To keep testing flowing smoothly there needed to be someone recording scores, chasing served balls, and returning the balls that have been served to the subject. Another limitation that was encountered was trying to keep as much as constant as possible, each ball had a different internal air pressure which affects flight, considerations were made as much as possible but some things are out of the experimenter's control. One software limitation is that body indexing is not a perfect science, and if the two joints overlap in view of the camera, it is difficult to separate them again and can cause the model to render in anatomically incorrect ways. For example, if the serving hand passes by the hip on that same side, which is proper technique, the camera will view the hand and hip as the same joint so the model will render with the forearm connected to the hip.

There are two different routes future studies could take using this experiment. The first is sticking with volleyball serving as the skill being improved. An avenue to be taken is using the current software and use the Kinect Infrared function to see if this is a more effective playback style. Alternatively, the software could be altered in a way that no coach is needed. There could be some form of feedback built in to the software that matches the server's joint data to show them what the proper technique is as they are serving to give a better visual of what the subject would need to do in order to improve their technique.

The other route that can be taken is as opposing to changing the software, change the task. A different task may mean that one form of playback is better than the other. In weightlifting it may be better to have body indexing for example, so the lifter can see how the joints are moving throughout the movement; but in rugby or football in regards to the skill of tackling it may be better to have the color playback so the player can see their full body position in relation to the person they are tackling. This experiment may not have shown what form of playback is better for a standing volleyball float serve, but it has opened the doors to using body indexing in the future for coaches of all activities and can be the basis for many experiments to come.

This experiment has shown us that there is not a statistically significant difference between using body index data and traditional color playback to improve volleyball serving accuracy. But body indexing shows a trend of more consistent higher percentage growth among servers who scored higher in their initial testing rounds, this could mean that coaches with highly experienced teams could use body indexing to coach their teams since logically a more expe-

rienced player would score higher in their initial rounds. Using this information coaches at all competitive levels will be able to increase their player's serving accuracy no matter the form of video playback in which they are using.

References

[Duarte et al., 2010] Duarte, R., Araújo, D., Fernandes, O., Fonseca, C., Correia, V., Gazimba, V., Travassos, B., Esteves, P., Vilar, L., and Lopes, J. (2010). Capturing complex human behaviors in representative sports contexts with a single camera. *Medicina (Kaunas)*, 46(6):408–414.

[Reeser et al., 2010] Reeser, J. C., Fleisig, G. S., Bolt, B., and Ruan, M. (2010). Upper limb biomechanics during the volleyball serve and spike. *Sports Health*, 2(5):368–374.

[Warade et al., 2012] Warade, S., Aghav, J., Claude, P., and Udayagiri, S. (2012). Real-time detection and tracking with kinect. In *Intl. Conf. Comp. Info. Tech*, pages 86–89. Citeseer.

[Zetou et al., 2002] Zetou, E., Tzetzis, G., Vernadakis, N., and Kioumourtzoglou, E. (2002). Modeling in learning two volleyball skills. *Perceptual and motor skills*, 94(3_suppl):1131–1142.