Video Analysis for the Tennis Coach

Introduction

Video is an extremely useful tool (and underrated!) for tennis coaching. It can be applied to skill acquisition, technique refinement, visualization, injury prevention, and coach education. Although video has been around for many years, it is only now becoming a common tool for the tennis coach and player. This is somewhat surprising, given the numerous benefits of using video and the relatively low cost of this technology.

Some of the benefits of using video technology in your coaching include:

- **Slow motion replay** – Tennis is a dynamic sport and most skills in the game are performed at speed. Given this, the ability of a coach to analyse these skills in detail using the naked eye is limited. Video allows you to view various skills in slow motion, again and again, and from different angles, which means you have an opportunity to analyse motion in great detail.

- **Developing models** – After a time, you can begin to see certain patterns of motion that are common among elite performers. Tennis strokes, for example, have a fundamental pattern that forms the basis of good technique. Using video, you can categorise these patterns, and form the basis of a model, in which to compare other performances. Video-based models are a very powerful tool in which to coach different tennis strokes, particularly when you are dealing with novice performers. Children, for example, will often try to emulate their favourite players from what they can see on television.

- **Tracking performance changes** – As a coach, you are required to analyse a player’s performance, and make alterations to technique based upon your knowledge of what you think is appropriate. Video can be a very useful tool for tracking any changes that occur as a result of your coaching. Filming a player’s technique several times during a session or season can reinforce the changes you are trying to make and give you and your player quality information. Keeping video records of players can provide positive feedback to you as a coach, as well as to the player, who can see that their hard work is paying off. It should also be noted that sometimes this video feedback can show that what you have been trying to achieve with your intervention is not working as well as you had hoped. This is also valuable information and can form the basis of different interventions for your player. So much of coaching and video analysis involves experimenting with different ideas. Video is therefore a valuable tool to help quantify your experiments.

- **Self reflection** – Many athletes believe that they are in a certain position when performing a skill, yet when they see themselves on video, it becomes clear that perhaps they are not quite where they thought they were! There is a ‘mismatch’ between what the player feels and the position they are actually in. Video is an excellent tool for correcting this ‘kinaesthetic-mismatch’. It is important for an athlete to ‘feel’ what it is like to perform the correct technique and seeing themselves performing a skill on video can be the first step to achieving a new movement pattern.

Historically speaking, video analysis has been a tool for sport scientists and biomechanists, which immediately brings forth bad memories in some coaches minds…numbers, tables, graphs, and equations that seem impossible to understand, and are somehow supposed to be related to coaching tennis! Although some aspects of biomechanics may involve complicated physics and mathematical concepts, this should not serve as a deterrent to the tennis coach who wants to apply biomechanics to their everyday coaching.

Biomechanics can be defined as the application of mechanics to biological systems and typically involves the analysis of forces and motion of the human body in an effort to enhance performance and reduce the risk of injury. Enhancing performance and reducing the risk of injury…isn’t this exactly what the tennis coach is trying to achieve? By this definition, the coach is already a biomechanist! The important thing to remember is that biomechanics has a wealth of knowledge to help you and video analysis is a way of applying the knowledge to improve your tennis coaching.

Learning to apply these tools in your everyday coaching is easy; just follow a few basic steps…
An Integrated Approach

Video Analysis should be thought of as a continual, integrated process, consisting of four main areas, shown below:

1. **Preparation**
   - Knowledge of the tennis skill
   - Identify critical variables

2. **Observation**
   - Correct viewpoint (side/front/rear)
   - Number of observations
   - Extended observation (fatigue)
   - Game or practice

3. **Evaluation**
   - Measure critical variables
   - Strengths & Weaknesses
   - Prioritise weaknesses

4. **Remediation**
   - Select appropriate intervention
   - Provide feedback
   - Modify the task
   - Split screen and voice feedback
   - Translate critical features into cues
   - Conditioning

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1. **Preparation**

Before you begin an analysis, you must first have some knowledge of the skill that you are analysing. This knowledge is often first hand, in that you have performed the skill yourself, and you are aware of the basic concepts of how the skill should be implemented and what the final result should be. However, you should be open to gaining knowledge from as many other sources as possible. These sources can include other coaches and players, or text books and scientific papers that focus on the skill. Do not limit yourself to tennis-specific information either, as you might be surprised at how much information you can apply to tennis from other sports.

Here are some links on the web that may provide you with some useful information on biomechanics and sport science:

- [http://www.sportsci.org](http://www.sportsci.org) : An excellent all-round sport science website
- [http://cwis.livjm.ac.uk/psd/DigitalResources/Biomechanics.htm](http://cwis.livjm.ac.uk/psd/DigitalResources/Biomechanics.htm) : Some other links..
- [http://www.humankinetics.com/](http://www.humankinetics.com/) : A good place to look for resources…check out Knudson and Morrison’s book on “Qualitative Analysis of Human Movement…it’s worth a read.

Given that you have adequate knowledge of the tennis skill you are analyzing, you should begin to think of some critical variables that you wish to assess. These variables can be thought of as key features of the performance that will lead to a successful outcome. So if your outcome is, for example, to achieve a faster serve, then you should be able to list a few key features of performance that are going to result in increased racquet speed.
Critical variables should be easily identifiable from video, so that you can assess these variables in step 3, and are typically body movements and sequencing of movements. Eg:

- Initiate leg-drive after ball toss (look for good range of knee flexion)
- Sequence of hip rotation followed by cartwheel motion of shoulders
- Look or adequate upper arm internal rotation, which can be seen by position of the racquet during the follow through.

Write these main points on a piece of paper with the players name for future reference. As this is a continual, on-going process, you don't want to forget what it is you are working on from week to week!

2. Observation

Achieving the best possible observation is a fundamental requirement in successful analyzing the motion. This includes gaining the correct vantage point to view the performance and assess the critical variables that you have determined in the preparation phase. You should also consider the number of observations you wish to make. If consistency is an issue, then you should look at multiple trials and compare them with each other. If you believe that performance is lacking due to fatigue, then you should analyse motion when a player is fatigued. At all times, you should try to analyse motion that is game-specific. It may be that your player performs well at practice, but under added pressure of a game situation, they do not perform as they should. In this circumstance you should try and get video footage from both scenarios for comparison and analysis. Do not underestimate the effect of psychological state on the motion being performed.

3. Evaluation

In order to provide useful information to the player, you should be able to assess critical variables as well as outcomes of performance. Correct evaluation will form the basis of your intervention, and you should be able to highlight both strengths and weaknesses of the performance. Never forget to highlight positive aspects of the performance.

Computer technology is making a presence in the area of video analysis, and its effect is felt mostly in the Evaluation and Remediation processes of the analysis. Computer software programs can be used to quantify critical variables, as opposed to making a subjective judgement (see below for more details on Computer Technology).

From your observations, you should be able to prioritise the weak aspects of the performance that require remediation. From this priority list, you can select a few critical variables to work with in your Remediation. When a player is working on their technique, he or she can only focus on a few key variables at one time, so being able to prioritise weaknesses is important in deciding which area to focus on. Often you find that solving one aspect of a performance will also fix problems that occur further down the chain, so try to work on problems that occur early in the performance of the skill.

4. Remediation

Perhaps the most important (and difficult!) part of the integrated analysis process is the ability to develop a successful intervention to improve performance or reduce the risk of injury. Performance goals should be outlined from your Evaluation phase so that your player has a clear idea of what you are trying to achieve. Setting realistic goals with performance outcomes will improve your chances of early success, which is crucial to changing technique.

For example, you may be working to improve a player's topspin backhand, and one aspect you have highlighted from your analysis is that the player does not initiate the swing low enough, and fails to come over top of the ball. You believe that by concentrating on starting the swing from a lower position, the player will produce more topspin upon ball contact. This may seem obvious, but the key here is to translate this knowledge into appropriate action with your player. You can develop some key phrases or 'cues' that should initiate an automated response, such as "racquet low and drive upward". Reinforce these cues during practice sessions and provide some immediate feedback on the outcome of the performance. Feedback may also be obvious, given the trajectory of the ball.
You should make it clear to the player that changing technique is a time-consuming process and they might expect to take a step backward before they can take two steps forward. Through continual feedback and reinforcement, new technique can be adopted and automated, but this takes time and effort. Video is a crucial tool in this process to provide feedback to coaches and players. As mentioned in Stage 3, recent advancements in computer technology allow for rapid analysis and feedback using video, and will be discussed in more detail below...

**Video Cameras**

*“If a picture is worth a thousand words, then how much is a video worth?”*

A video analysis is only as good as the video footage that you collect. Therefore, it is imperative that you know how your video camera operates and how to collect quality video footage.

**Basics**

A video camera works in a similar way to a still camera in that a ‘shutter’ sits between the lens and the film at the back of the camera. When the shutter opens, light is allowed to pass onto the film and an image is recorded. Of course, if you have a digital camera, instead of film at the back of the camera, there is an image sensor, which converts the light to a digital image. All video cameras have a setting that allows ‘shutter speed’ to be altered and it is important to find this feature on your video camera. Sometimes there is a button on the camera that actually says ‘shutter’ or ‘shutter speed’, whilst other cameras have a selected setting that will control the shutter, such as the ‘Sport’ mode on SONY’s range of cameras.

Having manual control over the shutter speed is important to ensure you have a clear, sharp image of the motion of interest. If the camera shutter is open for a long period of time while the object of interest is moving, the image will appear ‘blurred’ and this is often referred to as ‘motion blur’ (Figure 1). In auto-mode, a camera might try to open the shutter for a long period of time if you are filming in low light conditions. You should always manually select a shutter speed that is high enough to prevent image blurring. For most human movement, selecting a shutter speed of 1/250th or 1/500th of a second is adequate. If you want to get a clear image of the ball after it is struck by the bat, you may have a select a shutter speed around 1/4000th of a second. By increasing the speed at which the shutter opens and closes, you are also reducing the amount of light that enters the camera, so there is often a trade off between selected shutter speed and the light conditions where you are filming. If you are filming indoor then artificial lighting is often required to maintain good images with high shutter speeds.

*Figure 1. Two images taken from video during a serve. Image A has been taken with a high shutter speed (1/1000th sec), whereas Image B has been taken with a slower shutter speed (1/100th sec), resulting in ‘motion blur’ of the racquet.*
Note that the shutter speed is not to be confused with the frame rate of the camera. ALMOST ALL video cameras that you will buy off-the-shelf (both analog AND digital) have a fixed frame rate, depending on what camera system you are using. In Australia, New Zealand, UK, Asia, and the subcontinent, the video system used is PAL, which operates at 25 images/sec. The other system used is NTSC, which operates at 30 frames/sec (used in USA and Japan). This means that for every second of video that you shoot, the camera will record either 25 or 30 images (PAL or NTSC).

High speed video cameras are capable of capturing far more images per second (200 frames per second and beyond), but these cameras are very expensive ($10-20,000 USD) and are not likely to be within the budget of the average tennis coach!

Relatively low frame rates of standard video cameras also place a limit on what can be seen by the tennis coach. For example, you are not able to view the contact of the ball on the racquet with any precision, nor are you likely to see the spin on the ball as it departs from the racquet. More often than not, you will see the motion either side of these specific points of interest, as the frame rate is far too slow to capture all of these events.

**Digital or Analog**

Digital cameras have improved image quality (or resolution) over analog cameras, which are reflected in a slightly higher price tag. However, if you are only viewing your images on a small television and playing back the footage through a VCR, then the difference in image quality is not that noticeable. Where the differences really play a part is when capture the images onto a computer for further analysis. The digital recording process (DV out) means that you can connect the video camera to a computer and transfer video from the camera directly onto a hard disk through a fast connection called a ‘fire wire’ port (also referred to as “i-link” or “IEEE1394”). Fire wire ports are almost standard on laptop and desktop computers for the purpose of downloading video from digital video cameras and several video analysis software packages make the most of this new technology (see: www.siliconcoach.com).

**Tripod Use and Camera Positioning**

You should always try to use a tripod when filming. The tripod is not only useful for keeping the camera perfectly still, but it allows you to obtain camera views that are consistent from week to week, which is important if you want to make comparisons across different filming sessions. The tripod should be placed level to the ground and in a position that is going to allow you to observe the motion of interest. Many tripods have a ‘spirit level’ attached to enable an accurate positioning of the camera to the horizontal. It is often appropriate to position cameras in known, standardized positions relative to the motion that is being filmed. For example, when analyzing a tennis serve, typical camera positions include a front view (directly behind the net looking towards the server), a side view (in line with the serving line, about 5-10 metres back), and perhaps a rear view (~10 metres directly behind the player). Standardizing these positions enables you to collect consistent video footage that you can use for comparisons between different players or record a player’s progress week to week.

**Field of View**

Once you have positioned the camera correctly, use the zoom to increase the size of the image of interest, so that it takes up most of the screen. It can be helpful if you ask your player to stand in the position where they will be performing the skill in order for you to get the correct field of view. There is an obvious trade-off here between how much of the player you can see in the field of view, and how much detail you can achieve. For example, if you wish to analyse a serve and volley from a side camera, you are going to have a difficult time seeing fine details of the motion as the camera will have to be a long way away from the player to capture both the serve and the volley. Panning (moving) the camera during filming can be useful for maintaining the size of the player in the field of view as they move. However, it is more difficult to compare video footage from panning cameras, so using this technique in combination with fixed camera images is ideal.
The figure below illustrates two good positions to place cameras in order to analyse the tennis serve.

**Focus**

Most video cameras have an auto focus, which is useful for capturing images where the subject is always in the field of view. However, in circumstances where you have a fixed camera and the subject moves in and out of the field of view (e.g., they run past the camera), then the camera can struggle to adjust correct focus. In these instances, it is better to use a manual focus on your camera and adjust the focus prior to filming.

**Body Markers**

Whenever possible, ask your subjects to wear as little as possible, or in the least, have them wear tight clothing that will not mask the true motion of the body. It can be very difficult to analyse motion if athletes are wearing baggy clothes. Another way of improving the repeatability of measures taken from video is to use markers attached to various anatomical landmarks on the body. Even using a permanent marker to draw on subjects' skin can improve the repeatability of measures taken from a video analysis.

As well as placing markers on your subject, it is also a good idea to place markers on the ground or in the field of view, at a known distance apart. This can be useful for scaling and calculating distance and speed measurements, but the markers MUST be in the same plane of motion as the athlete to account for 'out-of-plane' perspective errors. If you know the distance between two markers, then you can easily determine the distance between any other 2 points in the field of view by using this known scaling factor. siliconCOACH Pro will calculate distance measures by using a known scaling distance.
Video Analysis Software

With the reduced cost of computer hardware and digital video cameras, the use of video analysis software in everyday coaching is becoming a realistic possibility for the tennis coach. To suit the needs of the coach, software packages such as siliconCOACH have been developed that are cheap, easy to use, and can provide immediate and powerful feedback to the athlete and coach.

The use of video analysis software has several advantages over the use of video alone. These include the following:

- Ability to capture images straight to the hard disk of the computer – you can hook up the video camera to a laptop computer and store images straight into the computer, without having to record onto a tape. This means you can provide on-the-spot analysis and feedback.

- Ability to display more than one screen at a time – split screen views have been shown to improve the learning of skills and can be used in a variety of ways:
  1. Show images of the same skill from different view points side by side. This gives you a better understanding of the real three dimensional motion that is occurring.
  2. Compare elite and novice players from the same view. Video footage of elite players is used as a model for the novice performer to compare. This can be a very powerful method of skill acquisition, particularly with younger players. But caution must be taken with this approach as we cannot hope to emulate a players individual style or flair. Rather, try to model the basic concepts of the skill.
  3. Compare the same player before and after remediation. Again, the use of split screen feedback is a powerful instructional tool. Immediately, the player and coach can see if a current remediation is having any effect on the technique or motion being performed. This model can be used to compare pre- and post-training, pre- and post-fatigue, or comparison of a players technique under different psychological conditions (ie: anxious vs relaxed).

- Use of drawing tools to emphasize coaching points. Coaches can use line tools and various other drawing tools to highlight areas of interest (see Figure 2), or to display what they are trying to achieve with their intervention.

Figure 2. Screen captures from siliconCOACH software, showing drawing tools, blended motion, angle and distance measurements.
Quick calculation of key variables. siliconCOACH Pro is a useful package as it also allows a coach to quantify key variables of interest. These key variables can be joint angles, timing differences, distance measures, or speeds. The use of a scaling factor (see Markers above) allows one to easily calculate a distance and a speed in the captured video. You can directly measure racquet speed as a performance criteria, then go about trying to improve racquet speed with a number of different ideas or remediation drills. Actual measurement of the performance provides a positive reinforcement of the work you are doing, both to the player and the coach.

Create presentations and reports. siliconCOACH Pro can also create a presentation of the coach’s analysis, with voice recordings and drawings all being saved to a CD that can be given to a player, or put onto the web. Presentations or reports can be automated by using a Technique Wizard (see Figure below), saving the coach time and effort in the long term. Many coaches shy away from new technologies because they have a tendency to distract from the main focus of ‘being a coach’. However, video analysis can be time effective and the rewards of using video by far outweigh the cost in analysis time. A single video analysis session can give similar or better feedback to a player than five sessions in the nets.

Video Analysis Checklist

1. Preparation – know the skill…write down the critical variables you wish to analyse
2. Video Set up – select a high shutter speed, correct focus and position the camera on a tripod in the most appropriate location to view the critical variables
3. Markers – ensure your subject is not wearing baggy clothes that may obstruct viewing
4. Collect video footage that is game-specific
5. If possible, use video analysis software to help perform the analysis and measure the critical variables. Compare with previous performances, or compare with a model performance
6. Provide positive feedback
7. Prioritise weaknesses and select a few key areas for remediation drills
8. Reinforce remediation with appropriate ‘cues’
9. Re-analyse – back to step 1!!
About the Author
Thor Besier completed an undergraduate degree in Physical Education from Otago University, New Zealand, where he was introduced to the subject of biomechanics and video analysis. Following an honours degree in Biomechanics in 1995, Thor headed to the University of Western Australia to complete a PhD in biomechanics, investigating mechanisms of knee ligament injuries and training methods to prevent injury. Dr Besier continued as a research associate in biomechanics, working with Dr. David Lloyd and Professor Bruce Elliott at the University of Western Australia until the end of 2002. During this time, he was a consultant to various professional sporting groups on the implementation of video analysis in coaching. Such groups included the International Tennis Federation, European Tennis Association, the British Lawn Tennis Association, sportscotland, and Institutes of sport within Australia. Dr. Besier is a biomechanics consultant to a New Zealand-based video analysis software company, siliconCOACH Ltd. Dr. Besier is currently a Research Associate at the Biomechanical Engineering Division at Stanford University, California, where he is investigating mechanisms of patellofemoral pain.

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