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Biomechanical Analysis of Stroke Production.

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ABSTRACT

Before discussing how biomechanics and technical analysis are integrally linked, it is important to understand the term biomechanics as it relates to stroke evaluation. Biomechanics provides an appreciation of stroke production and court movement from mechanical and anatomical perspectives. For the coach, with special reference to stroke production, this involves the following.

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INTRODUCTION

• How do I modify stroke production to improve performance? That is how does the player:

a. Hit the ball more powerfully with control;

b. Manoeuvre the ball to different parts of the court in order to create a better tactical game situation.

• How do I reduce the potential for injury in the following situations?

a. During player development as the body matures;

b. For the tournament player, who is required to repeatedly perform – how do I reduce the incidence and severity of overuse injuries?

To achieve these results requires an effective analysis structure. A systematic approach to analysis generally requires 5-stages (Fig 1) to permit the coach to 'see and then evaluate' what is happening during stroke production. Such an approach enables the coach to confidently analyse movements at all levels of development.

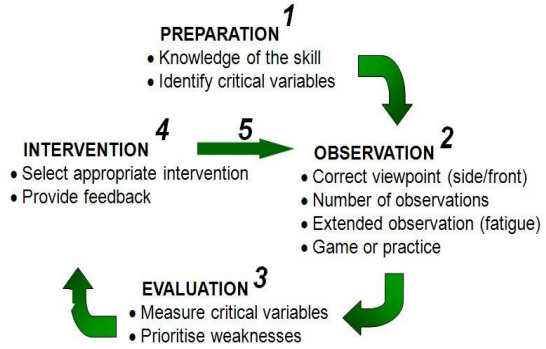

Figure 1: 5-stage analysis process – a key to effective analysis (Modified from Knudson and Morrison, 2002)

The Preparation Phase of the analysis process involves identifying the critical mechanical variables that underpin stroke development. Armed with the knowledge of these critical variables or key ingredients prepares you to observe and evaluate the performance of any stroke. Some of these critical variables include:

• Level of rotation of the hip and shoulder alignments in ground strokes (separation angles)

• Racket trajectory pre- and post-impact in creating'heaviness' in stroke production

• Level of knee flexion prior to the drive phase of the serve

• Positioning of the 'line of drive' from the feet through the lower limbs to the trunk in the serve

• The alignment of the racket and hand in a volley

All of these must be formatted in your mind prior to commencing the actual analysis and will likely change with player age (or even gender).

Remember:

• These critical features of stroke production will vary depending on the stage of player development. For example, in the serve, rhythm may be the most important aspect of early learning, whereas internal rotation at the shoulder may be an area needing development as players mature (i.e. for a 16-year old).

• The need for variability in stroke production will dictate that selected mechanical factors be emphasised at various stages of development (Elliott, Reid & Crespo, 2009). For example in 'building' a forehand, it is important that this be achieved by hitting balls of various heights, spin types and court locations.

In the world of biomechanics a coach may approach the analysis of stroke production in a number of ways:.

• Qualitative analysis – use of the eyes attached to a thinking mind (here, video may be used in the observation phase to provide more detailed and repeated viewings of performance). This is the type of analysis used by coaches on an everyday basis.

• 2D quantitative analysis – use of a video linked with appropriate software (e.g. Dartfish or Siliconcoach) to measure features of performance that are clearly 2D – that is, the movement is in one plane or by definition is planar. Obviously the software packages mentioned above may also be used to assist in qualitative analysis. For example you may draw a line on a sequence of frames (the head in a forehand drive) to qualitatively appraise some aspect of balance. Make sure that you place your camera perpendicular to the line of motion if you intend to measure any 2D angles or distances from the video.

• 3D quantitative analysis – this level of analysis would only be used with national level programs, where a player has problems with injury or power generation. Coaches can use data from 3D analyses of players to improve their ability to qualitatively analyse performance.

How then can a coach use biomechanics and the methods of analysis most readily available to them (Qualitative and 2D Quantitative) to shape their approach to technique development? Let me use a series of images from Andy Roddick's serve to explain. As a coach you may do some or all of the following. The points listed are examples of what may be performed and a comprehensive list can be found in Elliott, Reid and Crespo (2003, 2009).

With a sound understanding of the biomechanics of stroke production (preparation), the coach can analyse movement effectively (observe and evaluate) and then start the very difficult task of modifying motion (intervention) - by far the hardest part of the analysis structure. Remember, the learning pathway requires you to look for different mechanical aspects of stroke production at the various stages of development.

RODDICK SEQUENCE MECHANICAL FEATURE OF INTEREST	QUALITATIVE ANALYSIS	2D QUANTITATIVE ANALYSIS
	• Balance • Position of the racket and ball to body • Position of the feet relative to each other • Position of the hips and shoulders • Alignment of the trunk	• The distance between the feet • Alignment of the trunk (hips and shoulders)
	• Angle of the front arm (a characteristic of the Roddick serve, where he positions the ball closer to the body – permits good back hip drive) • Knee flexion and position of both knees (drive-line to the ball) • Hip and shoulder alignment rotations (both horizontal and vertical) • Position of the back to the front foot	• The inclination angles of the shoulder and hip alignments • Rotation of hip and shoulder alignments • The height of the ball toss compared with player standing height • The level of knee flexion
	• Position of the racket relative to back (away from the back and with respect to the hips) • Level of external rotation at the shoulder • Leg and particularly back-hip drive • Position of the head and front arm	• The position of the racket to the back • The velocity of the back-hip during the upward drive • Alignment of the forearm to the court (indicator of maximal external rotation at the shoulder)

	• Position of the head • The rotation of the trunk from A to D (check movement of the trunk about the 3 axes of rotation, particularly shoulder-over-shoulder) • Presence of internal rotation	• Flexion angle of the trunk • Hip alignment • Position of the back compared with front hip joint
	• Body positions at impact (vertical, forward-back and laterally with respect to body • Alignment of racket and forearm • Shoulder abduction angle • Trunk flexion • Position of head and non-racket arm	• Impact position (vertical, forward-back and laterally with respect to body • Alignment of the racket and the forearm • Shoulder abduction angle
	• Follow through of racket (include forearm pronation and shoulder internal rotation) • Landing position and preparedness for next stroke • Arabesque of back leg (following landing – not in image F) • Balance	• Landing position in the court – both forward and lateral • Flexion angle of the trunk

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