This month I want to introduce biomechanical terminology to readers and describe Amleto Monacelli’s physical game with these terms. Amleto, who has won 19 PBA titles (ranking 14th) and was named PBA Player of the Year twice, recently trained with us at the Kegel Training Center in preparation for the Pan American Games. Bowling has been an official Pan Am Games sport since 1991.

Since Amleto’s visit, I have reflected on how the use of biomechanical definitions could more accurately articulate the movements and positions of the physical game. Biomechanical terminology can provide coaches and players with a more extensive professional language. Specifically, with the standardization of terms, coaches and players can achieve a shared language to describe the physical movement of all bowlers, from beginners to elite players. Moreover, with the use of biomechanical concepts, coaches can more accurately test movement relationships and performance outcomes.

To begin, I present a number of important biomechanical definitions to help readers learn the appropriate language. After this introduction, I discuss Amleto Monacelli’s physical game utilizing these terms to help coaches and players understand the implementation of the expressions.

**Biomechanical terms**

**Forearm Supination/Pronation**

The neutral position for the forearm is the thumbs up position. When the hand and forearm face the ceiling, the forearm is rotated to approximately 90 degrees of supination. Conversely, when the forearm faces down, it is in approximately 90 degrees of pronation. According to both the American Medical Association (AMA) and the American Academy of Orthopaedic Surgeons (AAOS), the normal range of motion (ROM) for both forearm supination and pronation is 80 degrees.

**Wrist Flexion/Extension**

The neutral (0 degree) position of the wrist is the fingers straight and the hand aligned with the forearm. Flexion at the wrist involves movement of the palm of the hand toward the palm side of the forearm. In colloquial bowling...
slowinski at large

Step 1

slowinski at large

Step 1: Front View

slowinski at large

Step 1: Front View

slowinski at large

Step 1: Front View

Wrist Ulnar Deviation/Radial Deviation

Ulnar deviation is moving the wrist medially, toward the body. It is named for the ulna bone, a long bone on the inside (when the forearm is supinated) of the forearm. This is also known informally in bowling circles as cocking. Both the AMA and the AAOS rate the normal ROM for ulnar deviation as 30 degrees. Radial deviation moves the wrist laterally, away from the body. The radius bone is located on the thumb side of the forearm and is also a long bone in the forearm. The normal ROM according to both the AMA and the AAOS is 20 degrees.

Elbow Flexion/Extension

Elbow flexion is moving the forearm toward the upper arm and body. Extension refers to the movement away from the upper arm and body. In the set up of most bowlers, the forearm is supinated and flexed at ninety degrees or higher of elbow flexion. The AAOS states that the normal ROM is 150 degrees with 140 for the AMA. The neutral or zero position is the arm fully extended.

Trunk Lateral Flexion

Lateral flexion is leaning or bending the trunk to the side. For bowling, in the modern game, in order to establish an improved line of sight and space for the swing slot, lateral flexion is a critical element of an efficient game. The neutral or zero position would be standing straight. The normal ROM for the lower (lumbar) and middle (thoracic) spine is 30 to 35 degrees. In the October 2010 Slowinski at-large, I discussed the body position in which trunk lateral flexion helps create space for the swing slot as well as enhancing torso rotation.

Shoulder Extension/Flexion

In bowling terms, shoulder flexion (forward) and extension (backswing) are an important component of the physical
game. The neutral position of shoulder extension or flexion is at the side, adjacent to the leg. With the arm in front of the body, the shoulder is flexed slightly. Flexion is forward movement with a normal ROM of 150 (AMA) or 180 (AAOS). The normal ROM of extension is 50 (AMA) or 60 (AAOS) degrees. Pay special attention to the normal ROM in regard to shoulder extension. The height of the swing can only be achieved by trunk flexion.

Shoulder Adduction/Abduction

Abduction is to move the upper arm away from the body. Adduction is to move the upper arm toward your body.

Trunk Flexion

The normal ROM for the lower (lumbar) and middle (thoracic) spine is 80 (AAOS) and 60 (AMA) degrees.

Trunk Rotation

Some bowlers rotate the torso which places the ball-side hip and shoulder behind the balance arm side hip and shoulder.

Knee Flexion

Bending at the knee is knee flexion. The normal ROM is 135 (AMA) or 150 (AAOS).

Amlelo's setup

Formally, the set up is the preparation stage in bowling. This includes wrist flexion or extension, wrist ulnar deviation, elbow flexion, shoulder flexion, trunk/torso flexion, trunk/torso lateral flexion, shoulder extension, knee flexion, and forearm supination.

Wrist: As with most elite players, Amleto's wrist is slightly flexed and set slightly in the ulnar deviated position in the set up. Ulnar deviation is cocking the wrist.

Elbow Flexion: From the side view, with the ball held high in the stance, Amleto's elbow flexion is approximately 82 degrees in the set up position.
**Lateral Flexion:** In his set up, Amleto has one of the least amounts of side lean of elite players. Most players are in the 15 to 20 degree range. He is approximately 11 degrees, with zero degrees being standing completely straight.

**Forearm Supination:** Amleto’s forearm approximates the maximum supinated position in the set up.

**Shoulder Extension:** The neutral position of shoulder extension or flexion is at the side, adjacent to the leg. With the arm in front of the body, the shoulder is flexed slightly.

**Trunk Rotation:** Some bowlers rotate the torso which places the ball side hip and shoulder behind the balance arm side hip and shoulder. Amleto has nearly zero trunk rotation in the set up.

**Trunk Flexion:** Leaning slightly forward at the hips, Amleto has a small degree of trunk flexion.

**Knee Flexion:** Amleto’s knees are slightly flexed in the set up.

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**Describing Amleto’s swing start biomechanically**

As Amleto completes his first step, the trunk flexion angle increases as he bends forward. From step one, where Amleto has 82 degrees of elbow flexion, his shoulder and elbow extend, reaching 147 degrees by step two. The elbow is fully extended as it passed the leg into the upswing.

Laterally, trunk flexion increases slightly as he moves into the second step. As he completes his first step, he has moved from standing straight up to 38 degrees of trunk flexion by step two. This will increase to 48 degrees by the completion of step three.

**Describing Amleto’s swing biomechanically**

The swing will be defined as the upswing and downswing. As the forearm passes the leg, the angle of supination increases as the swing is hyperextended into the backswing.

As his hand leaves the ball and drops into the swing, Amleto’s balance arm remains extended and the elbow flexed. His forearm is pronated. As he transitions from step three...
to step four, Amleto’s balance arm moves forward, increasing the degree of the shoulder as well as elbow extension. Through these two steps, the balance arm forearm is pronated to approximately 90 degrees.

The trunk flexion angle, which was established at the end of step three, remains at 142 degrees through the 4th step ending at nearly 135 degrees. His lateral trunk flexion increases rapidly as the ball descends in the downswing. Moreover, on the downswing, torso rotation progressively decreases as the shoulder adducts.

**Describing Amleto’s release and follow through biomechanically**

Amleto is best known for creating a unique hand position at the top of the swing. Many bowlers over the past twenty years have attempted to emulate this move. His open position represents a very large forearm supination angle. In the downswing, for most bowlers, the forearm supination angle increases. In Amleto’s case, the forearm supination angle remains into the downswing. As the ball descends in the downswing, the trunk lateral flexion and shoulder adduction allow the elbow to move toward the hip and be close to the body. Moreover, as the ball descends, the elbow and wrist flexion increases. The combination places the hand under and to the inside of the bowling ball.

As Amleto’s elbow approaches his hip, the following can be documented. (1) The elbow is flexed; (2) The shoulder is adducted (moving toward the body) and the hyperextension angle of the shoulder is decreasing; (3) The forearm has maximum supination; (4) The elbow is now flexed; (5) The wrist is flexed (cupped) and has ulnar deviation (cocked).

To begin the release sequence, the shoulder abducts moving the elbow away from the body for a short period. The hand and the forearm begin to turn immediately following shoulder abduction. Accordingly, the forearm supination angle continues to decrease. Immediately following the start of the wrist and forearm turning, the elbow and wrist both extend with the wrist moving from ulnar deviation to the neutral position. Finally, the shoulder flexes and the arm fully extends.

As Amleto follows through, the elbow and wrist are both extended, promoting a flat spot. As the arm moves forward, the elbow extends. From a functional process in the release, as a bowler increases the axis of rotation, the supination angle will approximate zero as the hand approaches the neutral thumbs up position.

**Conclusion**

Biomechanical terminology provides a more accurate method to discuss the physical game of players. As with other professions, bowling coaches should strive to accurately articulate the biomechanical movements of elite players.

This is the first step in an ongoing project to implement biomechanics into the analysis of the physical game. I will continue to refine and more accurately interpret, reflect, and comprehend how the physical game interacts through the entire approach and leads to higher levels of performance. This will aid in helping all levels of bowlers more quickly improve technique.

A special thanks to my colleague Dr. Barry Wilson, Biomechanical Consultant at the National Sports Council in Malaysia.

**References**