KINETIC LINK - DOES IT EXISTS IN THE KUDA AND SILA SERVE KICKING TECHNIQUE OF SEPAK-TAKRAW?

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The purpose of this study was to determine if the kuda and sila kicking technique exhibits the kinetic link theory of proximal-to-distal sequencing. Seven Qualisys ProReflex MCU 1000 cameras operating at 240 Hz captured nine highly skilled male sepak-takraw players performing both the kuda and sila service technique. The best kuda and sila serve kick based on the highest ball velocity, net clearance and ball placement accuracy was selected and analyzed for final analysis. Comparisons of angular velocity histories of the thigh, shank and foot segment showed comparable thigh, shank and foot angular velocity patterns. No differences were observed for thigh, shank and foot angular velocities at ball-contact. Moreover, angular velocity pattern indicated that the kicking sequence for both kuda and sila technique does not exhibit the kinetic link theory of proximal-to-distal sequencing, except for he initial 10% from toe-off. As such, the kinetic link theory should not be applied to describe the kicking patterns of both kuda and sila service techniques. The implication to sepak-takraw coaches is to work on the technique of a single segment leg action to produce maximum momentum prior to ball-contact.

KEY WORDS: kicking, hybrid sport, net-barrier games

INTRODUCTION: The kuda and sila technique kicking movement (Figure 1) is unique only to sepak-takraw. The efficacy and superiority of the kuda technique have been generally acknowledged and accepted by coaches in producing significantly higher ball velocities as compared to sila technique. Hence, the technique is often used as an initial offensive serve strategy to gain scoring advantages. However, current kuda and sila technique interventions are subjective, often based on personal preferences via trial and error method and/or even guesswork. This increases the likelihood of overuse injuries due to improper technique and leads to impair performance.

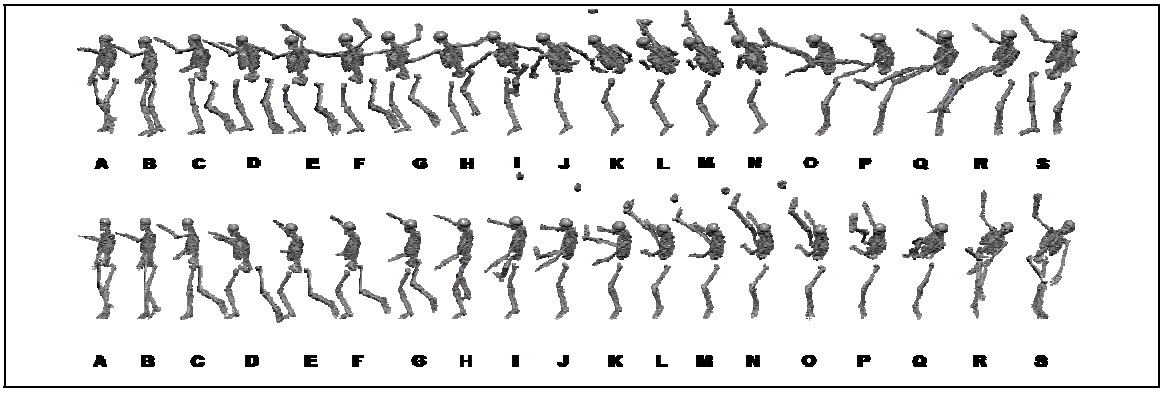

Figure 1: Motion sequence of kuda (top) and sila (bottom) serve technique in sepak-takraw

When analysing kicking kinematics, it was anderstood as a proximal-to-distal sequencing to obtain large velocities of the joint (representing an end-point). The kinetic link of proximal-to-distal system is a series of sequential activated body segment (Kibler, 1998). To achieve this, the sequence is often initiated first by the larger, heavier and slower central body segments; then, as energy increases, the motion proceeds outwards to the smaller, lighter and faster segments. This view is supported by much research (Barfield, 1998; Dorge, Bullandersen, Sorensen and Simonsen, 2002; Lees and Nolan, 1998; Levanon and Dapena, 1998; Putnam, 1993; Sorensen, Zacho, Simonsen, Dyhre-Poulson and Klausen, 1996). As highlighted in Figure 2, the operational definition of proximal-to-distal sequencing is typified kinematically by an increase in angular velocity of the more distal segment relative to the

adjacent proximal segment as the latter decelerates. In essence, the proximal-to-distal sequencing simply states that in order to produce the largest possible speed at the end of a linked chain of segments in kicking, the motion should start with the more proximal segments and proceed to the more distal segments, with the more distal segment beginning its motion simultaneously with the time when the proximal segment attains maximum speed. The end result is that each succeeding segment generates a larger end-point speed than the proximal segment.

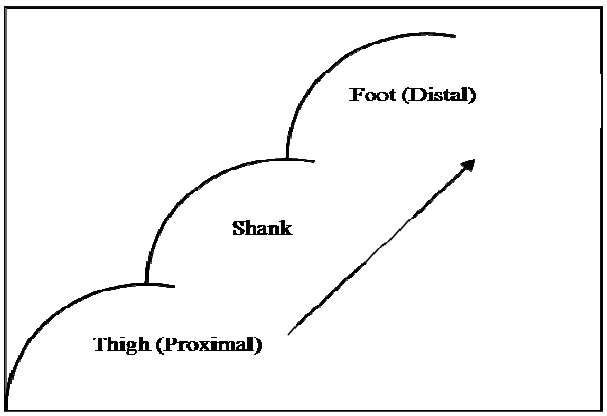

Figure 2: Proximal-to-distal sequential order of movement

Table 1 Direction of hip and knee joint SCS axes

	Positive (+ve)	Negative (-ve)
Hip joint	Extension	Flexion
	Abduction	Adduction
Knee joint	Extension	Flexion

Such sequencing is generally used to describe linear soccer kicking movements where ball velocities are correlated with angular and linear foot velocity at impact (Lees and Nolan 1998). While the objectives are the same, there is no evidence to suggest that both the kuda and sila kicking techniques will also exhibit similar proximal-to-distal sequencing; the specifics that relate to the segmental interactions of the *kuda* and *sila* serves are unknown due to the complex and unique nature of each kicking technique. The purpose of this study therefore is to see if the both the kuda and sila kicking technique exhibit the proximal-to-distal sequencing order of movement.

METHOD: Nine highly trained male sepak-takraw players performed 20 kuda and 20 sila serve trials. Each trial was assessed by a certified International Sepaktakraw Federation (ISTAF) coach and only the best kuda and sila trial (highest ball velocity, net clearance and ball placement accuracy) were selected for final analysis. Placement of seven Qualisys ProReflex MCU 1000 high-speed infra-red cameras (Qualisys Medical AB, Gothenburg, Sweden), operating at 240 Hz, ensured a convergence field of view between neighbouring cameras and provided a 360 degrees area of foci on the serving circle. Together with thirty-one reflective ball markers on selected anatomical landmarks (Maslan, 1997) a three-dimensional analysis of the kuda and sila serve was possible. 3-D space was calibrated using the standard Qualisys (749.5) '*L*' and '*T*' calibration frames. The kicking sequences for both kuda and sila technique were digitized and analyzed using the Qualisys Track Manager (QTM) and Visual 3-D (V3D) motion analysis software. A direct linear transformation (DLT) method established by Abdel-Aziz and Karara (1971) was used to generate the 3-D spatial coordinates and to ensure accuracy of the reconstructed 3-D coordinates. All selected kinematic variables were smoothed using Butterworth digital low-pass filter at a cut-off frequency of 7Hz. Kicking motion was analyzed from start of force production phase at toe-off (TO) to ball-contact (BC). Hip and knee flexion-extension range of motion and thigh, shank and foot angular as well as linear velocity time histories were analysed to gain an understanding of the segmental interactions of the kuda and sila kicking technique. Segment coordinates system (SCS) comprising of X, Y and Z-axis for hip and knee joints as well as for thigh, shank and foot segment centre of mass were aligned with the lab Cartesian global coordinate system. Hip and knee joint were defined as right thigh with reference to the pelvic segment and right shank with reference to thigh segment respectively. Hip and knee joint

flexion-extension is about the X-axis. Hip joint abduction- adduction is about the Y-Axis. Direction of hip and knee joint SCS axes is presented in Table 1.

RESULTS AND DISCUSSIONS: Results show comparable thigh, shank and foot angular (Figure 3) and linear (Figure 4) velocity patterns for both the kuda and sila service technique. As the kicking leg moves upwards at the start of force-production, kuda and sila thigh, shank and foot angular velocities increase. As the kicking leg swings past the stance leg, shank and foot angular velocity continues to increase whereas the thigh angular velocity decreases (Figure 3). The increase in shank and foot velocity and a decrease in thigh velocity could caused by negative thigh acceleration on positive shank acceleration as the knee begins to extend as the kicking leg swings inline with the stance leg. Such sequence is normally associated with the kinetic chain effect where in essence, each distal segment will only move when the preceding segment reaches maximum velocity and starts to decelerate (Barfield, 1998). However, as the kicking leg swings further upwards passing the stance leg, shank and foot angular velocities decreases whereas thigh angular velocity increases. This is contrary to the kinetic link theory. This implies that thigh, foot and shank move linearly upwards during the start of force-production and changes to a circular path in the transverse plane at the start of maximal knee extension as the kicking leg moves above hip level to accommodate point of ball-contact for both kuda and sila service techniques. The simultaneous increase in thigh, shank and foot angular (Figure 3) and linear (Figure 4) velocity pattern coming into ball contact proves that both kuda and sila technique kicking sequence do not exhibit the kinetic link theory of a segmental order of movement. For that very reason, we postulate that such theory should be used with caution when describing the kicking sequence of a kuda and/or sila technique in sepak-takraw.

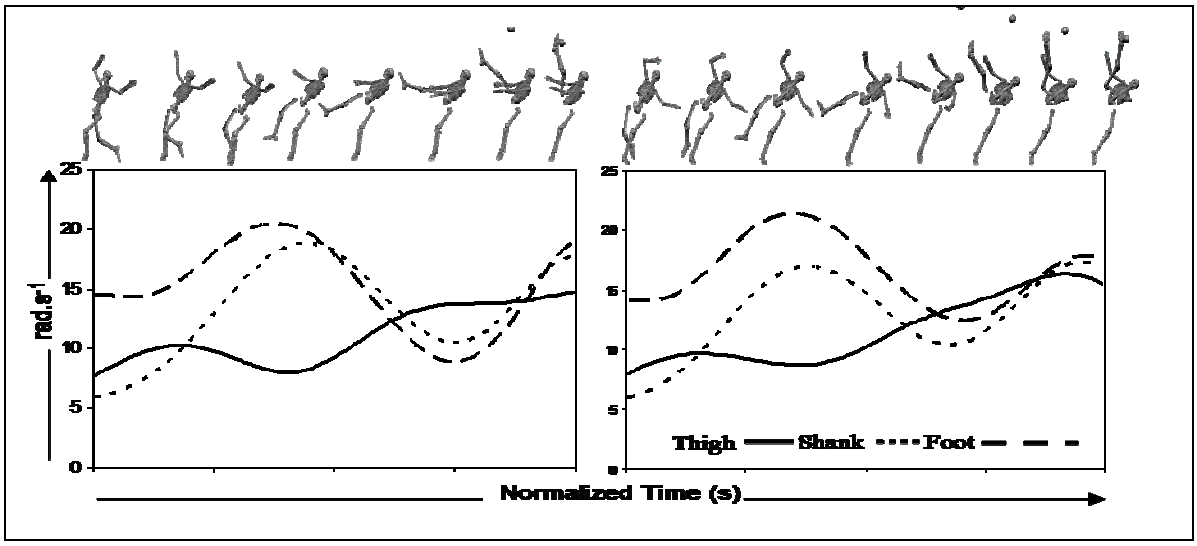

Figure 3: Thigh, shank and foot angular velocity pattern for kuda (left) and sila (right) serve technique from start of force-production (TO) to ball-contact (BC)

From Figure 4, the movements of the hip and knee flexion-extension are locked from the moment the kicking leg reaches maximal knee extension until just before impact. This shows that the leg moves as a single segment. However, just before impact there are minor adjustments in the kuda serve technique to accommodate point of ball-contact. The fluctuation is even greater in the sila serve technique. And this is possible because of the slower foot movement coming into ball-contact (Figure 3). The hip's range of motion during force-production for both techniques is small relative to knee joint. However the hip range of movement for the kuda is larger than the sila by about 10 degrees. This is attributed to the fact that the single segment is longer for kuda than sila and therefore possesses a larger moment of inertia. Although the kuda and sila kicking sequences do not exhibit the proximal-to-distal sequencing (Figure 3), the longer lever of the kuda technique, due to a smaller hip

flexion and a larger knee extension, generates a larger range of motion for the hip joint to build up the angular velocity to come into ball-contact.

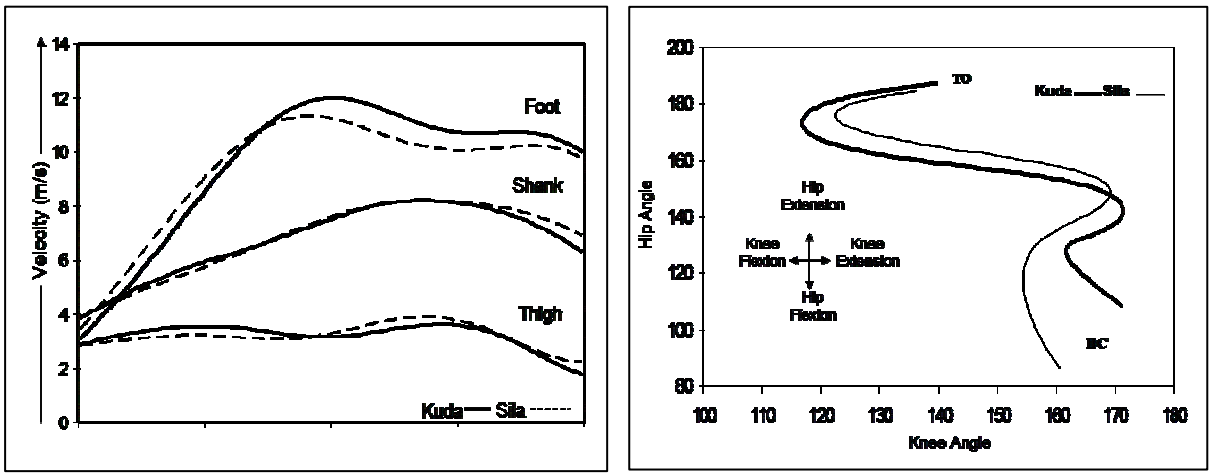

Figure 4: Thigh, shank and foot linear velocity (left) and hip and knee flexion-extension (right) for kuda and sila serve technique from start of force-production (TO) to ball-contact (BC)

CONCLUSION: An important characteristic of the kinetic link theory of proximal-to-distal sequencing is the decrease in angular velocity of the proximal segment while the distal segment increases to maximal value when coming into ball-contact. While such theory has been demonstrated in most kicking sports which demand maximum speed of the distal end segment in a kinematic chain (Lees, 2003; Lees and Nolan, 1998), angular (Figure 3) and linear (Figure 4) kicking leg segmental interaction data clearly show that the kuda and sila serve kicking techniques do not exhibit the kinetic link theory of proximal-to-distal sequencing despite demanding maximal foot angular velocity just before ball-contact. Such theory therefore is not a true representation of all kicking segmental interactions; in particular the kuda and sila serve technique in sepak-takraw. The implementation to coaches is to work on the technique of a single rigid kicking segment in order to achieve maximal foot angular velocity prior to ball-contact.

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