AP DOLLIO CHAGI KICK'S VARIABILITY BY CONTINUOUS RELATIVE PHASE IN ELITE TAEKWONDO MALE

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This study aimed to investigate the kicking limb coordinative patterns adopted by Taekwondo practitioners (Taekwondoka) during a roundhouse kick (Ap Dollio Chagi). Six Taekwondoka performed five repetitions of both kicks while kicking limb kinematics was recorded using a motion analysis system. Lower-limb coordination was quantified for hip and knee flexion–extension from toe-off to kick completion, using the Continuous relative phase (CRP). For all trials, across all participants, CRP curve peaks and maximum and minimum were determined. The CRP analysis highlighted, during the central portion of both kicks, a delayed flexion of the hip on the knee. Our findings suggested that there were a slight discrepancy in the pattern and variability of inter-joint coordination presented by CRP. This difference may be caused by the velocity (temporal evolution) and the normalization procedure involved in calculating CRP.

KEY WORDS: Taekwondo, continuous relative phase, kick

INTRODUCTION:

In martial arts, explosive actions are frequently performed in both combat competition or training, such that these activities represent an ideal model to investigate explosive non cyclic actions. However, the martial arts literature contains only one study investigating differences in coordinative patterns in Tae Kwon Does athletes across four different kicking techniques. Within the martial arts genre, Taekwondo is one of the most popular worldwide and represents a very demanding activity from the coordinative viewpoint (Sidthilaw 1997).

The authors provided a twofold interpretation of this finding. First that knee flexors were activated in directive to decelerate the shank prior to effect and secondly, that the biceps femoris acted, in its twofold role of bi-articular muscle, as a hip extensor.

Therefore, the study were to directly compare roundhouse kick's variability quantified by vector coding and CRP in Taekwondo, and to determine if these techniques convey similar information on variability (Sera 1992).

METHODS:

Experimental protocol

Following 15 min of a self-administered warm up, each participant performed five repetitions of the Ap Dollio Chagi Kick. Schematically, all kicking actions are initiated by flexing, abducting and externally rotating the hip; with concurrent knee flexion also occurring. Then, hip internal rotation and extension, and knee extension towards the target occur.

Data acquisition

Lower limb kinematics were acquired using a three dimensional stereophotogrammetric system (Vicon System, Motion Systems, Oxford, UK) recording at 120 samples/s. All subjects were equipped with twenty-three retro-reflective markers (14 mm diameter) firmly strapped with tape on the main anatomical landmarks of the pelvis and of thigh, and shank of the kicking limb (pelvis: Anterior and Posterior Superior Iliac Spines; thigh: Lateral and Medial Femoral Epicondyle; shank: Head of the Fibula, Tibial Tuberosity, and Medial and Lateral Ankle Malleoli).

Data processing

Each kick was analyzed during the interval delimited from the time instant when the kicking foot left the ground (toe-off – TO), computed as the minimum value of the antero-posterior component of the medial malleolus marker trajectory, to the time instant where the same marker reached the maximal antero-posterior displacement (final time – FT). The kicking action was time normalized and presented on a 0–100% scale. The variability of inter-joint coordination of CRP and VC was calculated as the average standard deviation of all points on the ensemble CRP and VC curves over a Roundhouse's Taekwondo for each subject, namely the deviation phase (DP). DP values represent the turn to return variability and a lower DP value indicates a more repeatable coordination between two joints.

Joint kinematics
Hip and knee joint kinematics were calculated, according to the Cardan convention, from the relative orientation of the relevant proximal and distal anatomical frames. For each trial, hip and knee flexion–extension angles were smoothed using a 3rd order zero-lag Butterworth low-pass digital filter with a cut-off frequency of 10 Hz. Hip and knee joint angular velocities were obtained deriving relevant angles. Peak flexion and extension angular displacements and velocities were identified using a custom written algorithm in Matlab (Matlab, the Mathworks, v7.9).

2.1. Vector coding

Vector coding was performed using the method of Sparrow et al. (1987). A phase plane was constructed, consisting of θ_1 on the x-axis and θ_2 on the y-axis. Coupling between θ_1 and θ_2 was quantified by the coupling angle θ_{VC} between consecutive coordinates in the phase plane

$$\theta_{VC}(i) = \tan^{-1}\left[\frac{\theta_2(i+1) - \theta_2(i)}{\theta_1(i+1) - \theta_1(i)}\right], \quad i = 1,2,\ldots,n-1$$

Where *i* indicates the point within the time series.

2.2. Continuous relative phase

Continuous relative phase (CRP) was performed using the method of Hamill et al. (1999). The state of each signal was assumed to be described by two state variable $\tilde{\theta}$ and $\tilde{\omega}$ with amplitude A and frequency f

$$\tilde{\theta} = A\cos(f\emptyset)$$

$$\tilde{\omega} = A\sin(f\emptyset)$$

A phase plane was constructed with $\tilde{\theta}$ on the x-axis and $\tilde{\omega}$ on the y-axis.

$$\emptyset(i) = \tan^{-1}\left[\frac{\tilde{\omega}(i)}{\tilde{\theta}(i)}\right]$$

Coupling was quantified by the CRP angle θ_{CRP}, which is the difference between the phase angles of two signals

$$\theta_{CRP}(i) = |\emptyset_1(i) - \emptyset_2(i)|$$

Where $\emptyset_1$ and $\emptyset_2$ are the phase angles for the first and second signals, respectively.

RESULTS: In this paper, first calculate angle of lower limb joints and then calculate the angular velocity of them. With sketch the angle-angle and angle- angular velocity diagram, analysis to be perfect. Figure1, show the angel-angular velocity diagram of Hip and Knee. Figure2, show the angle-angle diagram of Knee and Hip.

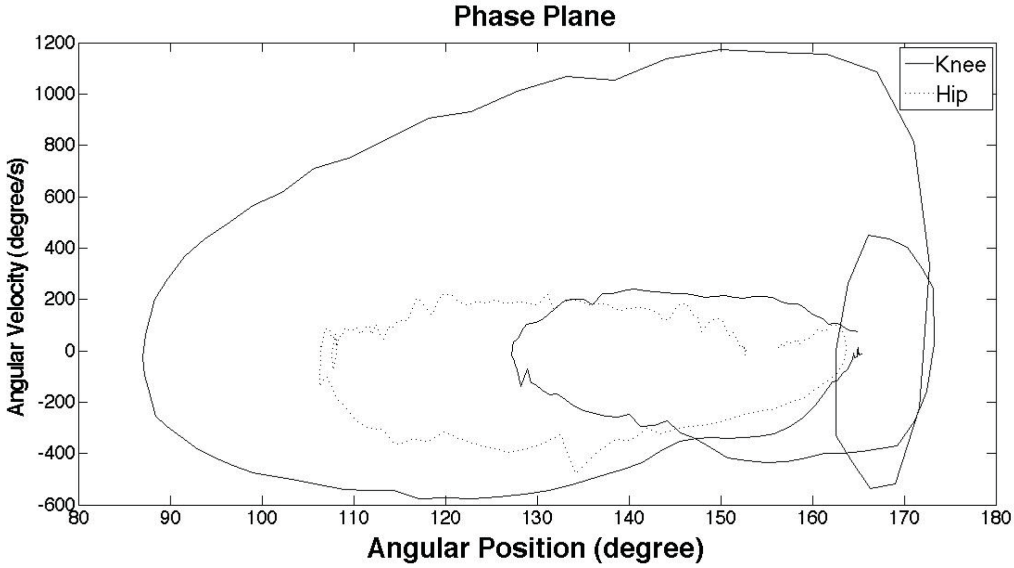

Figure 1: Angular Position-Angular Velocity of Hip and Knee joints

The pattern of inter-joint coordination of CRP and VC was compared by descriptive descriptions with in phase (CRP = 0° or ± 360°; VC = 45° or 225°) and out of phase (CRP = ± 180°; VC = 135° or 315°).

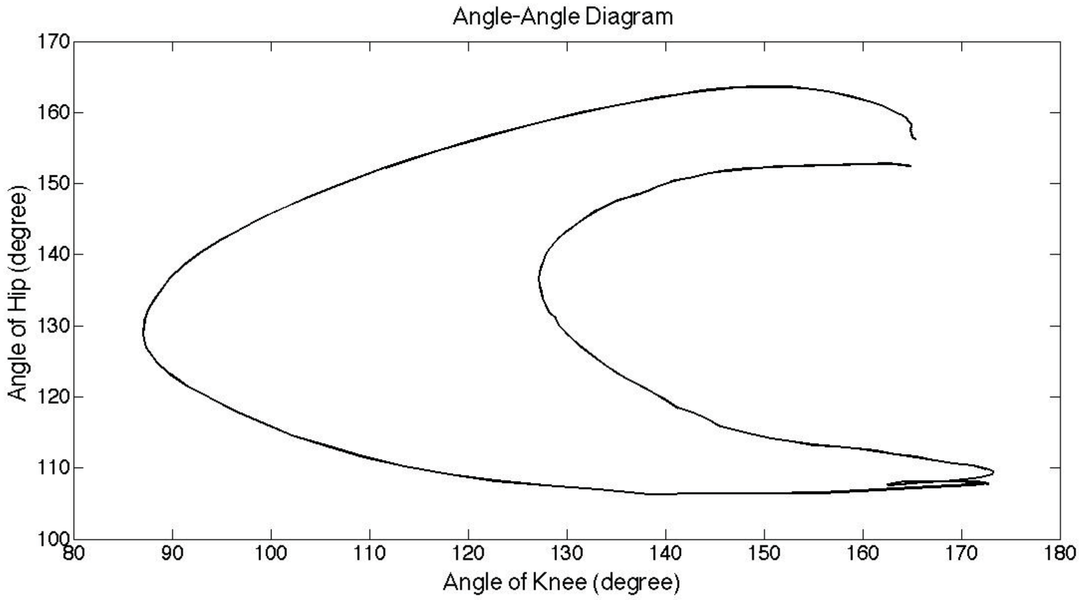

Figure 2: Angle (Knee)-Angle (Hip) Diagram

The alternations of coordination patterns between in phase and out of phase were generally in similar fashion in both techniques, except the initial contact of hip-knee coordination. While VC seemed to have greater ranges of fluctuations on the patterns than CRP, CRP seemed to have sharper inflexion points on knee-ankle inter-joint coordination than VC. The DP values for both hip-knee and knee-ankle inter-joint coordination were similar using both techniques, respectively (Table 1).

Table 1
DP values of inter-joints coordination (degrees)

Inter Joints	CRP	VC
Hip-Knee	0.17±1.23	0.77±0.11
Knee-Angle	0.15±1.03	0.83±0.09
Angle-Hip	0.02±0.96	0.82±0.11

DISCUSSION:

In figure1, loop area of the knee is larger than to the hip. It shows range of angular motion and velocity of knee are greater than the hip because knee joint play important role in Roundhouse kick's Taekwondo.
In addition, in figure1 and 2, all curved are close loop because roundhouse kick is cyclic technique and the leg of attach return to initial position. Figure2 has 2 step that relate to turn and return and consequently all from in-phase to out-phase and vice versa. In ideal state turn and return curved are unique and in this state player has full stable condition.

Our findings suggested that there was a slight difference in the pattern and variability of inter-joint coordination presented by CRP and VC in Taekwondo technique. This difference may be caused by the velocity (temporal evolution) and the normalization procedure that involved in calculating CRP. The coordination results obtained from CRP and VC might be comparable with cautions and concept of basic Taekwondo philosophy of Ap Dollio Chagi.

CONCLUSION:

Previous studies had successfully demonstrated that the control of human movement can be validated by using phase portraits of the motions of joints or segments. Hurmuzlu et al. (1994) has suggested that observing joint positions alone may be enough to identify the movement equilibrium during walking, however, phase portraits can be considered as useful tools to monitor the properties and changes of joints over time as they directly correlated the joint angles with respect to joint velocities. Since it has been indicated that the afferent fibers in muscle receptors work most efficiently by sensing joint position and velocity and a parameter missing the temporal evolution may potentially reduce its sensitivity to the variability, CRP may provide a higher level assessment of neuromuscular control as it can define joint position and direction of motions across multiple points of a gait cycle when compared to VC. Therefore, in the dissertation, we used CRP to investigate the inter-joint coordination and analysis of Taekwondo's Ap Dollio Chagi.

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