EFFECTS OF PERTURBATIONS ON KICKING LIMB CO-ORDINATION DURING THE *SEPAKTAKRAW* SERVE – A PRELIMINARY ANALYSIS WITH COACHING IMPLICATIONS

Ian Harris Sujae[1], Syahrial Bakhtiar[2], Wan Rizal Wan[1], Alex Ong[1], Joseph Hamill[3]

The School of Sports, Health and Leisure, Republic Polytechnic, Singapore[1]
Faculty Ilmu Keolahragaan, Universitas Negri Padang, Indonesia[2]
Department of Kinesiology, University of Amherst Massachusetts, USA[3]

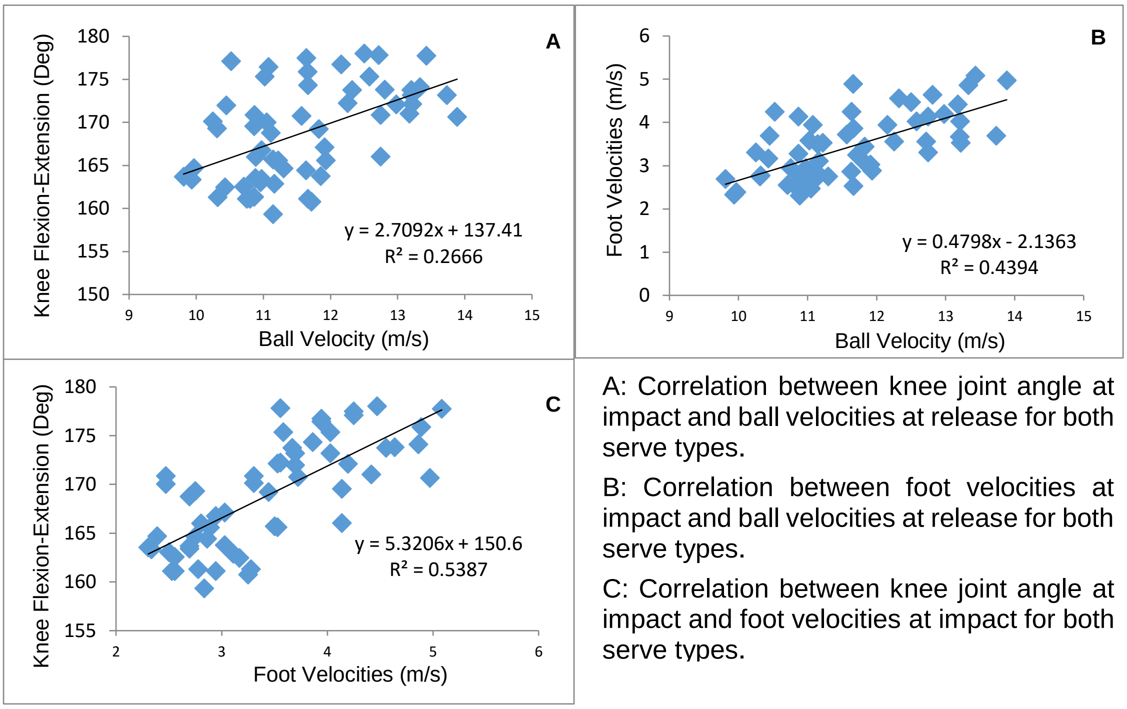
The purpose of this study was to describe kicking limb joint co-ordination between *sepaktakraw* serve techniques and to establish the effects of a perturbation on joint co-ordination when executing serve skills of different complexity to determine if the intended perturbations are required during training. A total of 25 *kuda* and 25 *sila* serve trials, performed by a trained male *sepaktakraw* player, were captured using a high-speed optical camera system. Kicking limb joint co-ordination differs between technique possibly due to differences in kicking kinematics. When subjected to perturbations (not receiving an ideal ball position in mid-air because the ball is tossed by another player), it took a longer time to return to normal *kuda* kicking patterns. Even with perturbations, players made adaptations to the kicking limb co-ordination and this strategy is key for repeated successful serves to unknown ball tossed positions in mid-air for optimal performance outcome measures. It is therefore recommended that perturbations be included during training so that, when perturbations occur, servers will be more aware of how to re-adjust their kicking patterns most quickly at the next serve.

KEYWORDS: *Sepaktakraw*, service perturbations, variability, movement patterns.

INTRODUCTION: The goal when executing any sports skill is consistency in technique or movement patterns. It is traditionally believed that this is key to optimal performance outcomes. Any variation in technique or movement patterns is a reflection of an incorrect execution of the skill that will inevitably lead to negative performance outcomes. It is, therefore, not surprising that athletes spend long hours of deliberate and repetitive practice to become consistent. Contrary to this concept, there is evidence to suggest otherwise. Variability in movement patterns is an adaptive mechanism utilized by athletes to find the best possible solution to the execution of the skill thus resulting in optimal performance outcomes (Chow, Davids, Button and Koh, 2006; Davids, Glazier, Araújo and Bartlett, 2003; Hamill, van Emmerik, Heiderscheit and Li, 1999; van Emmerik and van Wegen, 2000; Todorov and Jordan, 2002). This strongly suggests that any variation in movement patterns should not be reflection as error or improper execution of technique. While many of these studies investigated athletes of different abilities (i.e., skilled vs novice etc.), it is not known if the complexity of the skill would elicit similar mechanisms considering that, when executing simple skills, trained athletes require little concentration and cognitive ability to execute.
The *kuda* and *sila* serves are the two main types of service used in *sepaktakraw*. Compared to other net-barrier sports (tennis and volleyball), the ball is tossed by a team-mate to where the server points in mid-air when serving in *sepaktakraw*. Hence, the placement of the ball is rarely at the same exact spot (Sujae and Koh, 2008). In fact, there are occurrences when the position of the ball tossed is far off (perturbations). Regardless, the server must execute the serve whilst standing in the service circle. Failure to this results in a penalty. The sooner the server returns to a more consistent kicking pattern after such perturbations, the greater the chances of a repeated successful serve considering that variation in movement patterns are essential elements to normal function; one that offers flexibility in adapting to perturbations (Chow et al., 2006; Davids et al., 2003; Hamill, Haddad and Mc Dermott, 2000). Therefore, the purpose of this study was to describe joint co-ordination patterns between *sepaktakraw* serve techniques and to establish the effects of perturbations on kicking limb co-ordination when executing serve skills of different complexity in an attempt to determine if intended perturbations is required during training.

METHODS: A trained male *sepaktakraw* player (Age: 22yr), having competed at several international competitions representing the Singapore National Team and who was free from any musculoskeletal injuries, participated voluntarily for this study. Ten high-speed cameras (MAC Eagle 4, California, USA), operating at 240Hz, captured all 25 *kuda* and 25 *sila* serve trials performed. All cameras, secured onto overhead railings, captured a 360 degrees area of foci. A makeshift *sepaktakraw* court, with exact dimensions and nettings, were laid inside the lab complete with makeshift 'opponents' positioned across court to mimic actual competition. Throughout testing, the same team-mate (who has played together with the server for every international competition) tossed the ball into mid-air to ensure a consistent ball toss position. Perturbation trials is when the ball is purposely tossed to an unintended position (different points) in mid-air by the same team-mate. Blinded to the perturbation trials, the participant was instructed to kick the ball optimally to the designated target across court at every toss thus mimicking actual competition scenario. Passive retro-reflective markers were placed on the acromion process of scapula (left and right), iliac crest (left and right), greater trochanter of femur (left and right), lateral and medial epicondyle, lateral and medial calcaneus as well as on first and fifth metatarsal to establish the local coordinate systems for trunk, pelvis, thigh, shank and foot segments to measure knee joint angle and foot velocities at impact. Reflective tape was also attached onto the takraw ball to measure ball release velocities. Data were smoothed using the Butterworth low-pass digital filter at a cut-off frequency of 7 Hz and interpolated with a maximum gap fill of thirty frames using a 3rd polynomial established within the Visual 3D software. The initial range of cut-off frequencies, between 5 and 9 Hz, were selected based on the accepted cut-off frequencies used in published studies. The selected final cut-off frequency of 7 Hz was determined using residual analysis of raw data captured at different cut-off frequencies from a sampled serve trial (Chow et al., 2006). Pearson *R* correlation (≤0.4 and below weak, 0.5 to 0.6 moderate and ≥ 0.8 strong) was used to determine relationship between (i) foot velocity at impact and ball velocity at release, (ii) knee joint angle at impact and ball velocity at release, (iii) knee joint angle at impact and foot velocity at impact.

RESULTS: The *kuda* serve generated higher ball release velocities (12.3 m/s + 0.58 vs 10.9 m/s + 0.97), higher foot velocities (4.1 m/s + 0.50; 172.2 deg + 3.31) and larger knee angles at ball impact (2.8 m/s + 0.31; 164 .4 deg + 3.16) than *sila*. There was positive to moderate correlation between knee angles at impact and ball velocities at release (*r* =0.51) (Figure 1A), between foot velocity at impact and ball velocities at release (r =0.66) (See Figure 1B) and between knee angle at impact and foot velocities at impact (r =0.73) (See Figure 1C).



A: Correlation between knee joint angle at impact and ball velocities at release for both serve types.

B: Correlation between foot velocities at impact and ball velocities at release for both serve types.

C: Correlation between knee joint angle at impact and foot velocities at impact for both serve types.

Figure 1: Correlation values of selected measured variables.

A qualitative analysis showed differences in the kicking limb joint co-ordination between serve types from forward swing to impact. As the kicking limb swings forward, the hip joint flexed more and knee joint extends more than *sila (Figure 2)*. Qualitative analysis also showed that joint co-ordination between trails were disturbed in the presence of a perturbation; with greater variance for *kuda* (Figure 2, Cluster 2). Moreover, the server took longer time to return to normal kicking pattern when performing the *kuda* serve. The server returned to normal kicking pattern only in cluster 5 as compared to when performing the *sila* serve during which the server returned to normal kicking pattern immediately in cluster 3 (Figure 2).

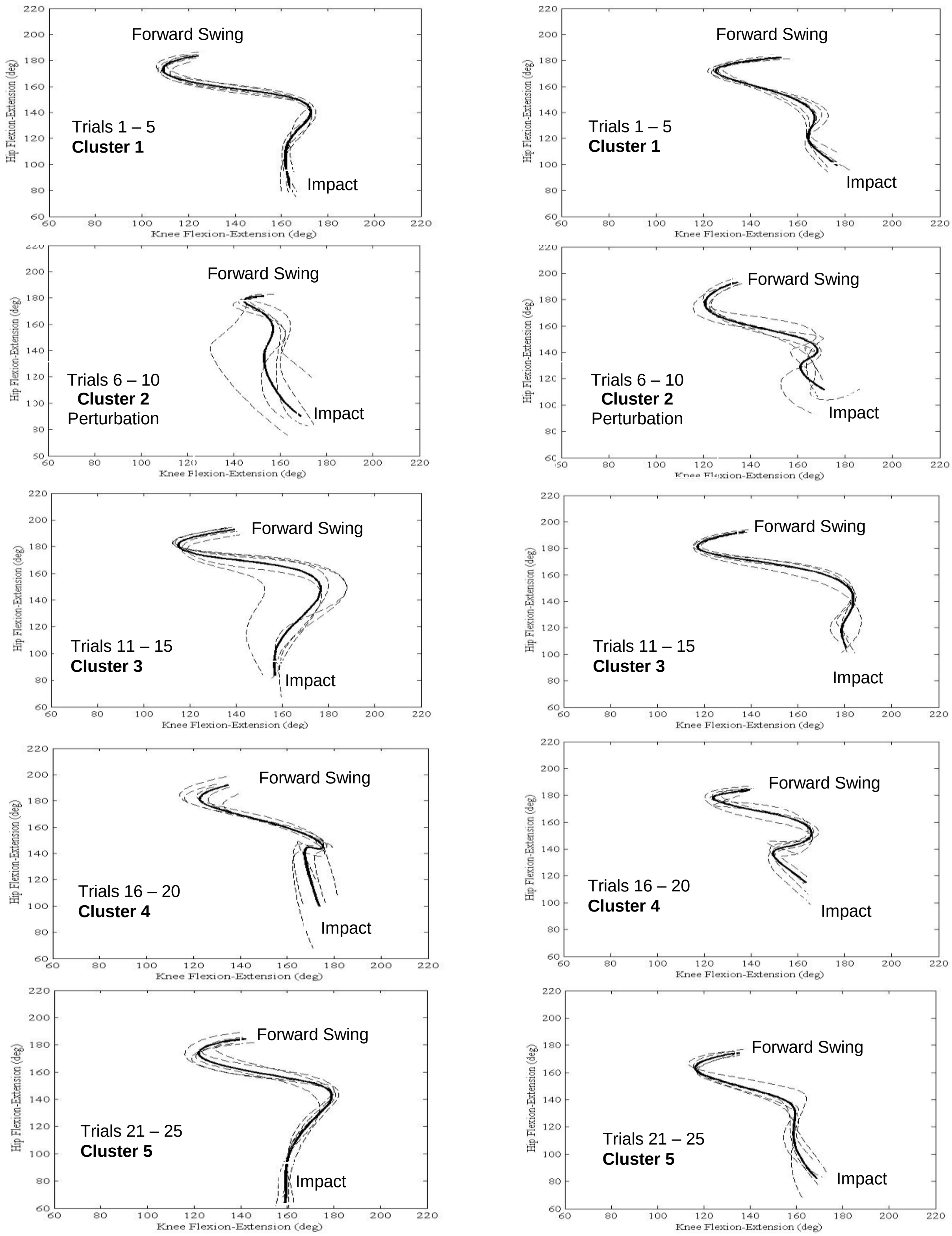


Figure 2: *Kuda* (left) and *Sila* (right) kicking limb hip-knee angle-angle plots.

DISCUSSION: The first objective of this study was to describe joint co-ordination patterns between the *kuda* and *sila* serve techniques. Differences in joint angle-angle plots of the hip and knee joint (Figure 2, cluster 1) suggest differences in kicking limb joint co-ordination pattern between techniques possibly due to differences in kicking kinematics. Each technique specific joint co-ordination pattern suggests that the kicking limb of each serve swings along its own distinct trajectory and this may be attributed to different ball placements at impact (Sujae and Koh, 2008). Even thoe the joint co-ordination patterns as seen in trials 1 to 5 were clustered close together, there is variations between trials and this suggests that variability in movement pattern when performing the serves may not be error or incorrect execution of technique but an adaptive mechanism utilized by trained *sepaktakraw* servers for optimal impact.
The second objective of this study was to establish if perturbation affects joint co-ordination when performing a more complex skill and that due to this, the ability to return to normalcy would be delayed. In Figure 2, joint co-ordination for perturbation trials 6 to 10 appears to be more varied than for trials 1 to 5; with *kuda* eliciting more variations than *sila* indicating that it was affected more by perturbations. Despite perturbations, the performance outcome of both techniques were optimal; with *kuda* ball velocities being faster than *sila* possibly due to faster foot impact velocities and a longer rigid segment at impact (larger knee joint angle) as reported in the literature (Sujae and Koh, 2008; Usman, Osman, Rambely and Abas, 2002;). It may also be that trained *sepaktakraw* servers were better at varying their movement patterns in adapting to ball toss positions for optimal performance outcomes. Studies have supported this suggestion (Chow, et al., 2006; Davids et al., 2003; Hamill et al., 2000). While joint co-ordination returns to the normal kicking patterns after perturbation, it took longer to return to normalcy when executing the *kuda* serve (at cluster 5) than *sila* (at cluster 3). From this, we could postulate that how fast or how slow the server returns to kicking patterns normalcy depends on the complexity of the skill. A major limitation to this study is that it was a qualitative assessment. A quantitative analysis may provide a better assessment of how perturbation effects kicking limb joint co-ordination when performing the *sepaktakraw kuda* serve technique.

CONCLUSION: There is a chance of not receiving an ideal ball position in mid-air when serving in *sepaktakraw* because the ball is tossed by another player. Regardless, servers must execute the skill by adapting their kicking limb co-ordination to impact the ball in mid-air. This strategy is key for repeated successful serves. It is equally crucial that servers quickly return to normal kick movement patterns after every perturbation, thus minimizing serving error. Since it took longer to return to normalcy when executing the *kuda* serve, it is strongly recommended that perturbations be included during training so that when a perturbation occurs, servers will be more aware of how to re-adjust their kicking patterns quicker at the next serve.

REFERENCES

Chow, J. Y., Davids, K. W., Button, C. & Koh, M. (2006). Organization of motor system degrees of freedom during the soccer chip: an analysis of skilled performance. *International Journal of Sport Psychology*, 37, 207-229.

Davids, K. W., Glazier, P., Araújo, D. and Bartlett, R. (2003). Movement systems as dynamical systems: The function role of variability and its implications for sports medicine. *Sports Medicine*, 33(4), 245-260.

Hamill, J., Haddad, J. M., & Mc Dermott, W. (2000). Issues in quantifying variability from a dynamical systems perspective. *Journal of Applied Biomechanics*, 16, 407–418.

Hamill, J, van Emmerik, R. E. A., Heiderscheit, B. C. & Li, L. (1999). A dynamical systems approach to lower extremity running injuries. *Clinical Biomechanics,* 14, 297-308.

Van Emmerik, R. E. A. & Van Wegen, R. (2000). On variability and stability in human movement, *Journal of Applied Biomechanics*, 16(4), 394-406.

Sujae I. H. & and Koh, M. (2008). Technique analysis of the *kuda* and *sila* serves in *sepaktakraw*. *Sports Biomechanics*, 7(1), 72-87.

Todorov, E. & Jordan, M. I. (2002). Optimal movement control and a theory of motor coordination. *Nature Neuroscience*, 5(11), 1226-1110.

Usman, J., Osman N. A. A., Rambely, A. S. & Abas, W. A. B. (2002). A comparative study on kinematics parameters between the sepak *kuda* serve and the sepak *sila*. In *Proceedings of Oral Sessions for the 20th Symposium of the International Society of Biomechanics in Sports, Caceres, Extremadura, Spain.*

ACKNOWLEDGEMENTS: The authors would like to thank the Singapore *Sepaktakraw* Association (PERSES) as well as Kenneth Toh, Vinidh Vijayakumaran, Sundram Ragagopal, Muhammad Hisyam and Jaron Tey Wei Jie for their contribution to this study.