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KINEMATICS ANALYSIS OF DOMINANT AND NON-DOMINANT LOWER LIMB DURING STEP AND JUMP FORWARD LUNGE IN BADMINTON

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ABSTRACT

This study was conducted to determine and compare the kinematics during step forward lunge (SFL) and jump forward lunge (JFL) in badminton. Fifteen university badminton players (mean age = 22.07 ± 1.39 years old) were recruited and were assigned to perform SFL and JFL while holding a badminton racquet using their dominant hand. Results showed that ascend time, descend time and time taken were significantly faster and the step distance was significantly greater in the dominant limb compared to the non-dominant limb during both SFL and JFL. To conclude, it is important for the coaches and athletes to reduce the performance asymmetries in order to enhance their performance in the court besides can decrease the risks of injury that might occur as a result of overuse of the dominant side.

Keywords: Step forward lunge, Jump forward lunge, Kinematics, Badminton

INTRODUCTION

One of the most important movement in badminton is the lunge (Farrokhi et al., 2008; Nadzalan, Mohamad, Lee, & Chinnasee, 2017). Forward lunge started with a front step followed by a backward push. In badminton, players usually used lunge to reach the shuttlecock. Forward lunge in a game usually performed with the lead leg been brought as far as possible to the front and returned back to stance position as fast as possible.

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It is important to analyse the movement performed because the information will give clearer picture on whether is there any deficiencies in the movement performed. For example, when the shuttlecock was sent to the front part of the court, the players will have the option whether to reach the shuttlecock by step in or by jumping. The knowledge on the description of motion will tell which movement is faster during ascend and descend phase, and how is the angle of the joints during the movement that is important for analysis of any injuries risk.

The lunge should be analysed in both dominant and non-dominant site of lower limb. This is to examine whether any bilateral deficit exist during the movement (Harun & Xiong, 2010; Nadzalan, Mohamad, Lee, Tan, et al., 2017).

Sturgess and Newton (2008) had highlighted the importance of the ability to accelerate from receiving stance to retrieving a drop shot. Athletes should accelerate quickly with the lunge to the shuttlecock because reaching the drop shot late will either result in an error or will enable the opponent to easily attack a poorly returned shot. However, having just a good acceleration is not enough as the strength to perform the lunge and maintain stable to reach the shuttlecock is also needed as this will allows them to a) reach difficult shots; b) execute an effective return shot; and c) conserve energy by executing the shot with comfortable body posture (Sturgess & Newton, 2008).

The aim of this study is to determine and compare the kinematics of the dominant and non-dominant limb during step forward lunge (SFL) and jump forward lunge (JFL) in badminton.

Participants

This study involved university male badminton players as study participants (n=15). Participants recruited were the currently active university representatives in any national university level badminton tournament. During this study, participants were required to perform two methods of badminton specific lunge (SFL and JFL). Participants performed all lunge exercises that had been randomized and counterbalanced between the participants in order to ensure results not affected by the order of tests.

All the participants selected were males aged between 20-25 years old based on their year of birth. Participants were screened prior to testing using PAR Q. Each participant read and signed an informed consent for testing and training approved by the Thaksin University Ethics Committee (CODE E 060/2559)

Step and jump forward badminton-specific lunge

Figure 1 and Figure 2 showed the step for SFL and JFL. Participants were instructed to stand with one of their hand (preferred) holding a badminton racquet, feet shoulder width apart. Participants lunged forward and must lower the thigh to 90º or parallel with the ground, and then returned back to the starting position. Participants were needed to make a big step as during downward position, the knee should not extend beyond the toe. The non-leading lower limb must not move from its starting position, and the head were constantly faced forward. As to simulate the movement used in real badminton game situation, participant bent their trunk to 45˚ forward. During descend movement, participants were required to act like in the badminton real situation in which the hand holding the racquet should be reaching a shuttlecock. Jump forward lunge were performed similar to the step forward lunge except participants need to explosively (jump) lunged forward and then explosively (jump) returned back also by jumping to the starting position. Participants were required to perform all the SFL and JFL for three trials consisting of three repetitions for each trial for both dominant and non-dominant lower limb.

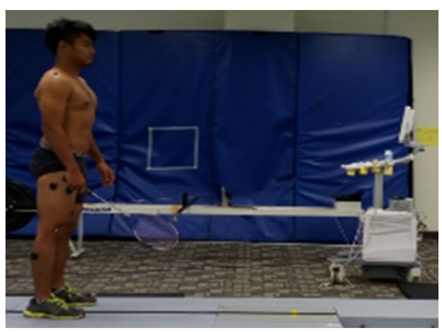

Fig.1. Starting and Ending Phase of SFL and JFL

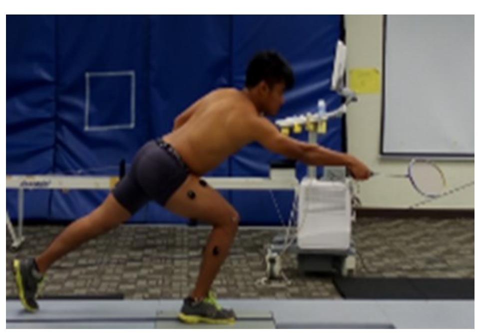

Fig.2. Descend Phase of SFL and JFL

MOVEMENT KINEMATICS

Motion analysis system (Vicon T10s, Oxford Metrics, UK) was utilized to collect kinematics data, sampled at 200 Hz. The kinematics data were smoothed using a Butterworth, low-pass filter with 6 Hz cutoff frequency for the marker trajectories. The kinematic model consisted of the trunk, pelvis, thigh, and shank of the front leg. The angles of the trunk, hip, knee and ankle were examined.

Joint angle of the ankle, knee, hip and trunk during maximum descend phase were analysed. Besides that, the ascend phase, descend phase and time taken to complete one complete repetition of lunge were also analysed. The descend phase were defined as the time taken from the starting of descend phase (when the participant start to move from starting position) to the ending of descend phase (when the participant has stop moved in the downward position). The ascend phase was defined as the time taken from the starting of ascend phase (when participant start to move upward from the ending of descend phase) to the starting position of lunge. Time taken for one complete repetition of lunge refers to the time taken for the participant to perform the lunge from the starting position (beginning of descend phase) until the movement completion (ending of ascend phase).

DATA COLLECTION

All participants involved in familiarization session in order to make sure all the participants were able to perform all the lunge movement correctly. Uniformed testing protocols were applied to all the participants. Participants were tested on three days to allow for full recovery and to avoid from contamination of test results due to inadequate recovery from earlier tests. The two days consisted of; (i) step forward lunge and ii) jump forward lunge test. All the tests were conducted in randomized order to minimise order effects. In order to ensure maximal performance, participants were instructed to “lunge as far as possible and as fast as possible”.

Movement kinematics of the stepping limb (dominant and non-dominant) was assessed during each test. Comparisons of those variables were made between each lunge protocols and between dominant and non-dominant limbs. All the familiarization and data collection sessions were supervised by the researcher with the assistance of appointed trained trainers.

All the lunge technique were closely monitored and controlled throughout all sessions. Participants were required to perform all exercises to a parallel depth as determined by the femoral line (line between the greater trochanter and the lateral epicondyle) being parallel to the ground (Nadzalan, Mohamad, Lee & Chinnasee, 2016). All lunge movement were performed as fast as possible to simulate the real game situation. All the training and data collection sessions were supervised by the researcher with the assistance of appointed trained trainers. All sessions were conducted at the Physical Conditioning Lab, UPSI, Tanjong Malim.

STATISTICAL ANALYSIS

Descriptive statistics were used to measure the mean and standard deviation of each physical characteristics and data scores. Repeated measure analysis of multivariances (MANOVA) was used to compare the difference of movement kinematics. Statistical significance was accepted at an α-level of $p \leq 0.05$. All statistical analyses were conducted using SPSS version 23 (IBM, New York, USA).

RESULTS

Table 1 showed the physical characteristics of participants involved.

Table 1. Physical Characteristics of Participants

Variables	Mean ± SD
Age (years)	22.07 ± 1.39
Body Mass (kg)	70.07 ± 1.88
Body Weight (N)	687.41 ± 13.53
Height (cm)	173.13 ± 2.12
1RM (kg)	71.87 ± 2.59
Relative 1RM (1RM/BM)	1.03 ± 0.01

DOMINANT LOWER LIMB

Analysis of dominant lower limb showed non-significant main effects were found in all the kinematics variables; i) ankle angle, $F(1,14) = 436.591$; $p > 0.05$, ii) knee angle, $F(1,14) = 3.18$; $p > 0.05$, iii) hip angle, $F(1,14) = 0.789$; $p > 0.05$, iv) trunk angle, $F(1,14) = 0.104$; $p > 0.05$, v) ascend time $F(1,14) = 3.027$; $p > 0.05$, vi) descend time, $F(1,14) = 159.108$; $p > 0.05$, vii) time taken, $F(1,14) = 17.079$; $p > 0.05$ and viii) step distance, $F(1,14) = 97.316$; $p > 0.05$.

Table 2. Kinematics Data of Dominant Lower Limb during SFL and JFL

Kinematics	SFL	JFL
Ankle Angle (˚)	65.33 ± 3.48	71.27 ± 3.04
Knee Angle (˚)	84.07 ± 2.69	84.20 ± 2.83
Hip Angle (˚)	82.80 ± 2.88	83.07 ± 2.79
Trunk Angle (˚)	45.80 ± 1.47	45.73 ± 1.28
Ascend time (s)	0.75 ± 0.03	0.79 ± 0.02
Descend time (s)	0.73 ± 0.08	0.72 ± 0.04
Time taken (s)	1.48 ± 0.05	1.51 ± 0.06
Step length (m)	0.89 ± 0.02	0.91 ± 0.03

Table 2 showed the kinematics data during the two lunge protocols. Pairwise comparison test showed no significant differences were found in all the kinematics data between step forward lunge and jump forward lunge, $p > 0.05$.

Non-dominant lower limb

Analysis of non-dominant limb showed non-significant main effect in all the kinematics variables; i) ankle angle, $F(1,14) = 445.474$; $p > 0.05$, ii) knee angle, $F(1,14) = 2.059$; $p > 0.05$, iii) hip angle, $F(1,14) = 0.157$; $p > 0.05$, iv) trunk angle, $F(1,14) = 2.642$; $p > 0.05$, v) ascend time $F(1,14) = 4.781$; $p > 0.05$, vi) descend time, $F(1,14) = 25.676$; $p > 0.05$, vii) time taken, $F(1,14) = 1.544$; $p > 0.05$ and viii) step distance, $F(1,14) = 93.129$; $p > 0.05$.

Table 3. Kinematics Data of Non-Dominant Lower Limb during SFL and JFL

Kinematics	SFL	JFL
Ankle Angle (˚)	68.13 ± 4.14	70.27 ± 4.10
Knee Angle (˚)	84.47 ± 3.40	85.13 ± 4.00
Hip Angle (˚)	83.67 ± 2.94	83.80 ± 2.31
Trunk Angle (˚)	46.60 ± 1.96	46.27 ± 1.67
Ascend time (s)	0.78 ± 0.02	0.77 ± 0.04
Descend time (s)	0.78 ± 0.04	0.80 ± 0.05
Time taken (s)	1.56 ± 0.06	1.57 ± 0.08
Step length (m)	0.85 ± 0.02	0.88 ± 0.03

Table 3 showed the kinematics data during the two lunge protocols. As in the dominant limb, pairwise comparison showed no significant differences were found in all the kinematics data between step forward lunge and jump forward lunge in the non-dominant limb, $p > 0.05$.

Step forward lunge (Dominant versus non-dominant lower limb)

Analysis of the dominant and non-dominant lower limb during SFL showed non-significant main effect were found in all the joint angle variables; i) ankle angle, $F(1,14) = 9.333$; $p > 0.05$, ii) knee angle, $F(1,14) = 3.500$; $p > 0.05$, iii) hip angle, $F(1,14) = 6.646$; $p > 0.05$, iv) trunk angle, $F(1,14) = 6.588$; $p > 0.05$. Significant main effect was found for the; i) ascend time $F(1,14) = 190.012$; $p < 0.001$, ii) descend time, $F(1,14) = 83.786$; $p < 0.001$, iii) time taken, $F(1,14) = 218.581$; $p < 0.001$ and iv) step distance, $F(1,14) = 201.232$; $p < 0.001$.

Pairwise comparison test showed that ascend time, descend time and time taken were significantly faster and the step distance was significantly greater in the dominant limb compared to the non-dominant limb.

Jump forward lunge (Dominant versus non-dominant lower limb)

Analysis of the dominant and non-dominant lower limb during JFL showed non-significant main effect were found in all the joint angles variables; i) ankle angle, $F(1,14) = 7.000$; $p > 0.05$, ii) knee angle, $F(1,14) = 6.792$; $p > 0.05$, iii) hip angle, $F(1,14) = 4.924$; $p > 0.05$, iv) trunk angle, $F(1,14) = 5.091$; $p > 0.05$. Significant main effect were found for the; i) ascend time $F(1,14) = 361.00$; $p < 0.001$, ii) descend time, $F(1,14) = 5.416$; $p < 0.05$, iii) time taken, $F(1,14) = 56.538$; $p < 0.001$ and iv) step distance, $F(1,14) = 231.00$; $p < 0.01$.

As in the SFL, pairwise comparison test showed that ascend time, descend time and time taken were significantly faster and the step distance was significantly greater in the dominant limb compared to the non-dominant limb during JFL.

DISCUSSIONS

In this study, ankle angle, knee angle, hip angle, trunk angle, ascend time, descend time, time taken for one complete lunge and step length of both dominant and non-dominant lower limb were assessed as the kinematics data. These data were compared between lunge protocols and between the dominant and non-dominant limb.

The strength of this current study was that the patterns of movement (kinematics) were closely monitored although they performed the lunge with different protocols. Participants were reminded to perform the correct technique of lunge during both descend and ascend phase. In this study, participants (university badminton players) were asked to performed step forward lunge (SFL) and jump forward lunge (JFL) with trunk forward erected, fast movement and the step should be as far as possible just to mimic the movement performed in the real game. Participants in this study were familiar with lunge exercises causing the need to accomplish the movement required were not difficult to be attained.

The analysis of the results showed no significant differences were found in all the kinematics data between SFL and JFL, in both dominant and non-dominant lower limb.

Results demonstrated that whether performing step or jump forward lunge, participants showed no differences in terms of movement kinematics. These findings were in contrast to what have been found in several previous studies that found different methods of lunge caused different kinematics responses (Farrokhi et al., 2008; Flanagan, Wang, Greendale, Azen, & Salem, 2004). Although were not found to be significantly different, the descend time was shown tend to be faster compared to the ascend time. Thus, this demonstrated the ability for the participants to reach the shuttlecock faster compared to the time they took to returned to the ready position in the court.

Results demonstrated descend phase was found to be faster compared to ascend phase during SFL and JFL. Because there are not much loadings and the ability to control the eccentric movement during SFL and JFL, participants did not put too much control during the descend phase. The non-significant differences of time taken during descend and ascend phase during SFL and JFL suggested that badminton players could performed any of these two movements when trying to reach the shuttlecock.

Besides the comparison between lunge protocols, this study also compared the biomechanical responses of dominant and non-dominant lower limb. This is the first known study that had compared the kinematics differences of dominant and non-dominant lower limb during lunge movement.

No significant differences were found for all joint angles between dominant and non-dominant lower limb. However, dominant lower limb was found to achieve faster ascend phase, descend phase and time to complete 1 repetition of lunge. Dominant limb was also showed to achieve greater step length. These conditions were applied to all the lunge protocols conducted. These findings thus showed that imbalances existed between dominant and non-dominant limb during lunge movement. Badminton players might be lack of advantageous if the shuttlecock is sent to the non-dominant side. Inability to move fast in the non-dominant side might cause the opponents to notice the players' weakness. The findings of this this current study was in contrast to those found by study conducted among martial artists that found no significant difference of dominant and non-dominant lower limb kinematics when performing kicks (Falcó et al., 2009; Harun & Xiong, 2010; Tang, Chang, & Nien, 2007).

The slower movement in the non-dominant side reflect the lack of strength compared to the dominant side. Strength imbalances between dominant and non-dominant side need to be reduced as it has been shown that these imbalances could increase the risk of injuries to the weaker and even stronger sides (Niu, Wang, He, Fan, & Zhao, 2011; Sadeghi, Allard, Prince, & Labelle, 2000; Wang & Cochrane, 2001; Zifchock, Davis, Higginson, McCaw, & Royer, 2008).

CONCLUSIONS

The faster dominant side will be more preferable to be used by athletes during the games thus can cause the dominant side to be overused while the strength gap with non-dominant side will become bigger. Coaches and athletes need to stress the important of non-dominant side training to reduce the imbalances for improving performance besides to reduce the risk of injury.

REFERENCES

Falcó, C., Alvarez, O., Estevan, I., Molina-Garcia, J., Mugarra, F., & Iradi, A. (2009). Kinetic and kinematic analysis of the dominant and non-dominant kicking leg in the taekwondo roundhouse kick. Paper presented at the ISBS-Conference Proceedings Archive.

Farrokhi, S., Pollard, C. D., Souza, R. B., Chen, Y.-J., Reischl, S., & Powers, C. M. (2008). Trunk position influences the kinematics, kinetics, and muscle activity of the lead lower extremity during the forward lunge exercise. Journal of Orthopaedic & Sports Physical Therapy, 38(7), 403-409.

Flanagan, S. P., Wang, M.-Y., Greendale, G. A., Azen, S. P., & Salem, G. J. (2004). Biomechanical attributes of lunging activities for older adults. Journal of Strength and Conditioning Research, 18(3), 599.

Harun, H., & Xiong, S. J. (2010). The symmetry in kinematics between the dominant and non-dominant legs in taekwondo turning kick. Unpublished. Degree thesis, Universiti Teknologi Malaysia, Skudai, Malaysia.

Nadzalan, A. M., Mohamad, N. I., Lee, J. L. F., & Chinnasee, C. (2016). Relationship between lower body muscle architecture and lunges performance. Journal of Sports Science and Physical Education, 5(2), 15-23.

Nadzalan, A. M., Mohamad, N. I., Lee, J. L. F., & Chinnasee, C. (2017). The effects of step versus jump forward lunge exercise training on muscle architecture among recreational badminton players. World Applied Sciences Journal, 35(8), 1581-1587.

Nadzalan, A. M., Mohamad, N. I., Lee, J. L. F., Tan, K., Janep, M., Hamzah, S., & Chinnasee, C. (2017). Muscle activation analysis of step and jump forward lunge among badminton players. Journal of Engineering and Science Research, 1(2), 60-65.

Niu, W., Wang, Y., He, Y., Fan, Y., & Zhao, Q. (2011). Kinematics, kinetics, and electromyogram of ankle during drop landing: A comparison between dominant and non-dominant limb. Human Movement Science, 30(3), 614-623.

Sadeghi, H., Allard, P., Prince, F., & Labelle, H. (2000). Symmetry and limb dominance in able-bodied gait: a review. Gait & posture, 12(1), 34-45.

Sturgess, S., & Newton, R. U. (2008). Design and implementation of a specific strength program for badminton. Strength & Conditioning Journal, 30(3), 33-41.

Tang, W., Chang, J., & Nien, Y. (2007). The kinematics characteristics of preferred and non-preferred roundhouse kick in elite Taekwondo athletes. Journal of Biomechanics, 40, S780.

Wang, H., & Cochrane, T. (2001). Mobility impairment, muscle imbalance, muscle weakness, scapular asymmetry and shoulder injury in elite volleyball athletes. Journal of Sports Medicine and Physical Fitness, 41(3), 403.

Zifchock, R. A., Davis, I., Higginson, J., McCaw, S., & Royer, T. (2008). Side-to-side differences in overuse running injury susceptibility: a retrospective study. Human Movement Science, 27(6), 888-902.

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