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Research article

FASCICLE BEHAVIOUR ANALYSIS OF STEP AND JUMP FORWARD LUNGE AMONG BADMINTON PLAYERS

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Abstract

Journal of Sports Science and Physical Education 6(2): 36-44, 2017 – This study was conducted to determine and compare the fascicle behaviour 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. Fascicle length, pennation angle, lengthening and shortening velocity of their vastus lateralis muscle were analysed using ultrasonography method. In both dominant and non-dominant lower limb, FLmax, FLmin, PAmax and PAmin were all greater during JFL compared to SFL, $p < 0.001$. During both SFL and JFL, all the fascicle behaviour variables were greater in the dominant limb compared to non-dominant limb. To conclude, as the fascicle behaviour response would indicate more muscle adaptation, the stimuli were found to be greater during JFL compared to SFL.

Keywords: step forward lunge, jump forward lunge, badminton, fascicle lengthening, pennation angle

INTRODUCTION

The study of fascicle behaviour during movement has been conducted in several previous studies especially during walking, running and squat (Earp, 2013; Earp, Newton, Cormie, & Blazevich, 2014; Finni, Ikegawa, & Komi, 2001; Finni, Ikegawa, Lepola, & Komi, 2003; M Ishikawa, Finni, & Komi, 2003; Ito, Kawakami, Ichinose, Fukashiro, & Fukunaga, 1998; Reeves & Narici, 2003) and the results showed the fascicle behaviour to be different with various movement patterns. For example, study on fascicle behaviour during jumping has shown greater vastus lateralis fascicle lengthening and shortening in submaximal compared to maximal vertical jumps, although the joint going through the similar range of motion (M Ishikawa et al., 2003). In contrast, Finni et al., (2001) found greater eccentric loading in drop jumps resulted in more tendon and less fascicle lengthening.

The knowledge on the fascicle behaviour during movement is important as the acute responses during the specific movement could cause different adaptations in the future. Fascicle behaviour during training can affect muscle architectures. Muscle architectures have been found to be correlated with sport/exercise performance (Abe, Kumagai, & Brechue, 2000; Earp et al., 2011; Earp et al., 2010; Kumagai et al., 2000; Nadzalan, Mohamad, Lee, & Chinnasee, 2016). Despite has been studied in other types of movements, to the authors' knowledge, the study of fascicle behaviour during lunge movement was scarce (Nadzalan, Mohamad, Low, Ahmad, & Waqqash, 2017). It is important to get to know the stimuli presented during the different methods of movement as it can affect the structural adaptations (Nadzalan, Mohamad, Lee, & Chinnasee, 2017).

In sport, one of the most performed lunge technique is the forward lunge. Forward lunge started with a front step followed by a backward push. In order to enhance its effectiveness, the forward lunge can be performed with the lead leg been brought as far as possible to the front as in the maximum descent phase (thigh parallel to the floor), the knee should not exceed the toe. Badminton is one of the sports that involved a lot of lunge movement in the game (Farrokhi et al., 2008). The important of lunge in a game could be seen when the player want to retrieve a drop shot where the player need to do a deep lunge to get to the shuttlecock.

Previous researches had been conducted on analysing the biomechanics of different techniques of lunge (Escamilla et al., 2010; Farrokhi et al., 2008; Gresham-Fiegel, House, & Zupan, 2013; Jönhagen, Halvorsen, & Benoit, 2009; Kim & Yoo, 2013), however, lack of data existed on the fascicle behaviour during the forward lunge movement. Therefore, the purpose of this study is to determine and compare the fascicle behaviour of both dominant and non-dominant lower limb during step (SFL) and jump forward lunge (JFL).

METHODOLOGY

Participants

This study involved university male badminton players as study participants (n=15). During this study, participants were required to perform two methods of badminton specific lunge (SFL and JFL) in random order. Participants were screened prior to testing using PAR Q. Each participant read and signed an informed consent for testing and training approved by Sultan Idris Education University.

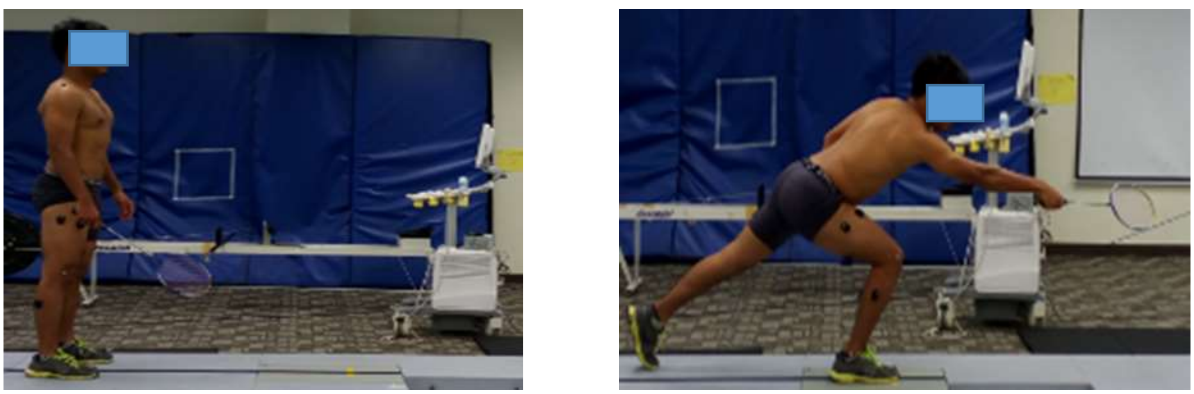
Procedures

Step and jump forward badminton-specific lunge

Figure 1 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 be 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 descent 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.

Figure 1 (a) and (b): Forward lunge performed in this study

a b



Fascicle Behaviour

B-mode ultrasonography (F37, Aloka, Ltd, Tokyo, Japan) (Figure 3.16) were used to obtain images of the VL fascicles for determination of fascicle length and fascicle angle throughout the movement. A 6 cm linear array, 13-MHz T-head transducer (UST 5413, Aloka Ltd, Tokyo, Japan) were used to collect images at 96 Hz. The transducer were placed at 50% of the distance between the greater trochanter and the lateral condyle of the femur and aligned with the direction of the VL fascicles so that the echoes delineating a single fascicle could be tracked throughout the entire range of motion of the knee (Earp et al., 2014). A thin echo-absorbent reference strip was fixed to the subject to allow for correction of any probe movement that occurred during the testing. The transducer head were fixed to the subject using a custom-made thermoplastic cast and were taped into place.

Ultrasound images were analysed using Java-based image processing program software (ImageJ, National Institutes of Health, Bethesda, MD, USA). An individual fascicle was tracked throughout the movement and the fascicle length and pennation angle from the deep aponeurosis were recorded for each image. Maximum fascicle length was defined as the greatest distance of fascicle from superficial aponeurosis to deep aponeurosis while the minimum fascicle length was the shortest fascicle distance from superficial aponeurosis to deep aponeurosis. Maximum pennation angle was defined as the greatest pennation angle of fascicle from superficial aponeurosis to deep aponeurosis while the minimum pennation angle was the smallest pennation angle of fascicle from superficial aponeurosis to deep aponeurosis. Shortening and lengthening velocities of the fascicle were calculated as the change in length over time during the movement.

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".

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 fascicle behaviour. Statistical significance were accepted at an α-level of $p \leq 0.05$. All statistical analyses were conducted using SPSS version 23 (IBM, New York, USA).

RESULTS

Physical characteristics

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

Dominant lower limb

Analysis of the dominant lower limb showed non-significant main effect for the; i) lengthening velocity (LENvel), $F(1,14) = 16.656$; $p > 0.05$ and ii) shortening velocity (SHOvel), $F(1,14) = 0.087$; $p > 0.05$. Significant main effect was found for the; i) maximum fascicle length (FLmax), $F(1,14) = 122.657$; $p < 0.001$, minimum fascicle length (FLmin), $F(1,14) = 162.885$; $p < 0.001$, maximum pennation angle (PAmax), $F(1,14) = 61.560$; $p < 0.001$, and minimum pennation angle (PAmin), $F(1,14) = 34.571$; $p < 0.001$.

Table 2

Fascicle Behaviour Data of Dominant Lower Limb during SFL and JFL

Variables	SFL	JFL	*p*-value
FLmax	14.09 ± 1.85[b]	15.08 ± 1.77[a]	0.000
FLmin	5.01 ± 0.81[b]	5.37 ± 0.83[a]	0.000
PAmax	21.13 ± 1.86[b]	22.06 ± 1.70[a]	0.000
PAmin	9.61 ± 0.92[b]	10.05 ± 1.07[a]	0.000
LENvel	19.75 ± 2.48	20.17 ± 2.40	0.062
SHOvel	17.77 ± 1.61	17.76 ± 1.58	0.081

Table 2 showed the fascicle behaviour data during the two lunge protocols. Pairwise comparison test showed that FLmax, FLmin, PAmax and PAmin were all greater during JFL compared to SFL, $p < 0.001$. No significant differences were found comparing the lengthening and shortening velocity between both lunge protocols, $p > 0.05$.

Non-dominant lower limb

Analysis of the non-dominant lower limb showed a non-significant main effect for the; i) lengthening velocity (LENvel), $F(1,14) = 5.470$; $p > 0.05$ and ii) shortening velocity (SHOvel), $F(1,14) = 0.987$; $p > 0.05$. Significant main effect was found for the; i) maximum fascicle length (FLmax), $F(1,14) = 4.571$; $p < 0.001$, minimum fascicle length (FLmin), $F(1,14) = 386.675$; $p < 0.001$, maximum pennation angle (PAmax), $F(1,14) = 43.941$; $p < 0.001$, and minimum pennation angle (PAmin), $F(1,14) = 36.466$; $p < 0.001$.

Table 3

Fascicle Behaviour Data of Non-Dominant Lower Limb during SFL and JFL

Variables	SFL	JFL	*p*-value
FLmax	13.94 ± 1.85[b]	13.92 ± 1.86[a]	0.000
FLmin	4.84 ± 0.82[b]	5.37 ± 0.83[a]	0.000
PAmax	20.80 ± 1.88[b]	21.62 ± 1.73[a]	0.000
PAmin	9.17 ± 0.96[b]	9.68 ± 1.09[a]	0.000
LENvel	18.97 ± 2.58	19.28 ± 2.41	0.086
SHOvel	16.83 ± 1.57	16.77 ± 1.55	0.072

Table 3 showed the fascicle behaviour data during the two lunge protocols. Results showed that FLmax, FLmin, PAmax and PAmin were all greater during JFL compared to SFL, $p < 0.001$. No significant differences were found comparing the lengthening and shortening velocity between both lunge protocols, $p > 0.05$.

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

Analysis of the dominant and non-dominant lower limb during jump forward lunge showed significant main effect were found for all the fascicle behaviour; i) maximum fascicle length (FLmax), $F(1,14) = 189.00$; $p < 0.001$, ii) minimum fascicle length (FLmin), $F(1,14) = 123.754$; $p < 0.001$, iii) maximum pennation angle (PAmax), $F(1,14) = 152.772$; $p < 0.001$, iv) minimum pennation angle (PAmin), $F(1,14) = 168.028$; $p < 0.001$, v) lengthening velocity (LENvel), $F(1,14) = 76.095$; $p < 0.001$ and vi) shortening velocity (SHOvel), $F(1,14) = 142.732$; $p < 0.001$. Pairwise comparison test showed all the fascicle behaviour variables were greater in the dominant limb compared to non-dominant limb during SFL.

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

Analysis of the dominant and non-dominant lower limb during jump forward lunge showed significant main effect were found for the; i) maximum fascicle length (FLmax), $F(1,14) = 145.694$; $p < 0.001$, minimum fascicle length (FLmin), $F(1,14) = 162.885$; $p < 0.001$, maximum pennation angle (PAmax), $F(1,14) = 142.242$; $p < 0.001$, and minimum pennation angle (PAmin), $F(1,14) = 112.326$; $p < 0.001$, v) lengthening velocity (LENvel), $F(1,14) = 104.584$; $p < 0.001$ and vi) shortening velocity (SHOvel), $F(1,14) = 147.433$; $p < 0.001$. As during the SFL, pairwise comparison test showed all the fascicle behaviour variables were greater in the dominant limb compared to non-dominant limb during JFL.

DISCUSSIONS

Currently, lack of study has been conducted on the fascicle behaviour during lunge movement. Previous studies on fascicle behaviour has been conducted on other training exercises (Duclay, Martin, Duclay, Cometti, & Pousson, 2009; Earp et al., 2014; Franchi et al., 2014; Hoffren, Ishikawa, & Komi, 2007; M Ishikawa et al., 2003; Masaki Ishikawa & Komi, 2004; Kawakami, Muraoka, Ito, Kanehisa, & Fukunaga, 2002) and walking and running (Cronin & Finni, 2013; Lai et al., 2015; Mian, Thom, Ardigò, Minetti, & Narici, 2007; Panizzolo, Green, Lloyd, Maiorana, & Rubenson, 2013).

Maximum fascicle length (FLmax), minimum fascicle length (FLmin), maximum pennation angle (PAmax), minimum pennation angle (PAmin), lengthening velocity (LENvel), and shortening velocity (SHOvel) of vastus lateralis were assessed and compared between lunge protocols in this study. The major findings of this study were that FLmax, FLmin, PAmax and PAmin were all greater during JFL compared to SFL while no significant differences were found comparing the lengthening and shortening velocity between both lunge protocols, $p > 0.05$. These conditions were seen in both dominant and non-dominant limb.

Results demonstrated that performing a movement with jumping will increase the response of fascicle behaviour. The fascicle was found to have greater maximum and minimum value of fascicle lengthening and pennation angle. With greater pennation angle, muscle will be able to produce greater force (Earp, 2013; Manal, Roberts, & Buchanan, 2006). No differences were found for the lengthening and shortening velocity between SFL and JFL.

CONCLUSIONS

In this current study, we have found that all the fascicle behaviours responses were shown to be greater in the dominant limb compared to the non-dominant limb. The greater fascicle lengthening, velocity and pennation angle in the dominant lower limb could affect the outcomes of the movement in terms of the kinematics, muscle activity and kinetic response compared to non-dominant limb. More studies were suggested to be conducted to explore the relationships between all these variables.

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