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Research article

THE INFLUENCE OF SUPPORTING LEG ON STRENGTH AND BALANCE DURING MAXIMAL INSTEP KICK TOWARDS KICKING PERFORMANCE AMONG UPSI FUTSAL RECREATIONAL PLAYERS.

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Abstract
Journal of Sports Science and Physical Education 3(1): 25-40, 2015 - The purpose of this study was to determine the relationship between supporting leg strength and supporting leg balance; and their correlation with kicking performance. Thirty four recreational male futsal players with a mean age 23.2±1.5 years old voluntarily participated in this study. Physical characteristics of participants (age, weight, height and body mass index) were recorded prior to test. Force platform was used to record kinetics variables during maximal instep kick (with and without target) and during the Balance Stork Test. Ball flight after impact with the kicking foot was recorded using high speed video camera set at 120 frame per second, with 500 hertz shutter speed. Ball velocity was then calculated using motion analysis software. Pearson correlation was used to determine the relationship between variables. Results indicated no significant correlation between maximal vertical force (max-vGRF) with the ball velocity for both condition of kicks; between strength (max-vGRF) and balance (at 95% ellipse area) of supporting leg; between supporting leg balance and ball velocity; between supporting leg balance and ball accuracy. However, negative significant correlations exist between max-vGRF and ball accuracy. Max-vGRF and ball velocity for both kicking without target and kicking with target was found highly correlated. As a conclusion, kicking performance was not primarily influenced by either the supporting leg strength (MVF) or supporting leg balance (95% ellipse area).

Keywords: *supporting leg strength, balance, maximal instep kick, ball velocity, accuracy.*

Introduction

Futsal had begun to be recognized in all corners of the world (Moore et al., 2014), with indoor court availability makes the sport become more attractive to be played due to convenient and safety, especially during bad weather condition (Duarte et al., 2009; Esteban et al., 2009). In addition, quantification of movement analysis during futsal game by biomechanists had promoted more interest on the game, especially with result of the study can be used to guide players practice (Bases, 2008).

Excellent performance of futsal players can be determined by evaluating their playing performance which consist of physical, psychological, and technical factors (Shan & Westerhoff, 2005; Stølen et al., 2005) with kicking is one of the primary essential ability (Barfield et al., 2002; Lees & Nolan, 1998). In futsal, kicking is known as one of the most specific technique that requires the player to be more creative in doing his kicking (Polidoro et al., 2013; Clark, 2007). Therefore, substantial attention about this skill from a biomechanical perspective is very crucial. Previously focus was on kinematics of kicking, while kinetics study on futsal kick is nearly non-existence. Kicking toward the goal or sometimes called shooting is very important which considered as operational target in futsal (Werlayne, 2012; Irokawa et al., 2010). Since size of the futsal field is smaller compared to the football with limited space for movement, shooting using the maximal instep kick had been chosen due to its ability in producing greater ball velocity toward target and quick to perform (Nunome et al., 2006; Barfield et al., 2002). Kinematics study on the maximal instep kick usually focus on the behavioural of the kicking leg (Nunome et al., 2006). However, the potential strength and balance on supporting leg related to shooting in futsal had not been clearly explored (Moore et al., 2014).

Movement can only occur with the presence of strength (for example: ability to exert force to move the intended musculature) and in the case of maximal instep kick, large number of muscles need to properly be integrated and coordinated for greater force and accuracy (Nunome et al., 2006; Coburn et al., 2005). Supporting leg seem to act as the arc strength for the body to execute the kick when ground reaction force transmitted, integrated and coordinated during the kicking movement (Shan & Westerhoff, 2005). Increase in supporting leg strength will promote balance and joint ability, which allow best positioning for maximal flexion and extension of the swing leg (Valdez, 2003).

Balance ability on supporting leg is essential in maintaining the body at its best supporting position at the moment of planting the supporting leg (Kawabata et al., 2013; Lees, et al., 2009). Thus, it allows the vertical ground reaction force to transfer the energy for coordinating the greater swing of kicking leg.

The influence of supporting leg in futsal kick had received little attention in term of research with various contradicting findings in field soccer based research (Moore et al., 2014; Lees & Nolan, 1998). This was supported by Sidaway et al., (2007) when they postulated that most test on kicking had intensively focused on the leg performing the kick, but studies on supporting leg are rare, especially, which involves futsal players.

Due to this it will be interesting to investigate the influence of supporting leg strength and supporting leg balance, and inspect significant correlation between variables. Thus, this study aims to identify the relationship between strength and balance components of supporting leg with the ball velocity and accuracy during the maximal instep kick.

Methods

Participants

Thirty-four UPSI futsal recreational male player's with age 23.2 ± 1.47 years old, weight 64.83 ± 8.96 kg, height 1.67 ± 0.34 m, and BMI 23.17 ± 2.98 kg/m^2 participated voluntarily in this study. Participants were ensured able to kick the ball using correct instep kick technique. All participants were in good health during test and were declared free from physical or orthopaedic injury which could prohibit participant from executing maximum instep kicking.

Procedures

Participants were tested in two different types of test, Balance Stork Test (BST) and Maximum Instep Kicking Test (MIKT). Before starting the BST and MIKT, physical characteristics profile which consist of age, height, weight, and body mass index (BMI) of participants were measured and recorded. Every single participant was asked to stand still on the middle top of the force plate (OPT400600-1000, AMTI Inc, Watertown, MA), facing straight towards the target wall in front, located six meters away, during recording of body weight. Participants' body weight had been recorded in the SI unit, kilograms. While, height of participants were measured in meter by using height scale that was attached to the wall. BMI of participants was calculated via formula [weight (kg) divided by the squared of height (m2)]. Participants had been given two minutes to get ready before they execute the real trial of BST.

The assessment of balance using the BST has been proven to be reliable and high in validity, considered as a functional test for balancing on the single leg which typically useful for normal gait and crucial for daily life and sports activities such as kicking (Barbara et. al., 2007). Every participants need to stand straight while their supporting leg foot had been placed on the middle top of the force plate, facing forward directly to the wall target. Instruction had been given when participants was ready. Measurement has started simultaneously when participants lift up their kicking leg, medial-flexion close to the knee and hold for about 60 seconds, standstill with both arm at the side of the hip. An instruction to stop the BST was given when time reaches 60 seconds. The result of the test was produced by the AMTI Acquisition Software version 3.05.00. The raw data were then transferred to the spread sheet and were used for descriptive and inferential analysis.

***Figure 1*:** Single Leg Balance Stork Test

The warming up was done by performing some stretch exercises and pre-instep kicking for 3 minutes prior to the performance of the real test (MIKT). Then, participants were given 2 minutes active rest before start executing the first trial of MIKT. Number of trials for this study had been chosen in accordance to the previous research (Ahsan & Ruru, 2014), that is 3 trials for kicking without target and 3 trials kicking with target. Increasing the number of trials will increased performance stability (James Watkins, 2007; Salo et al., 1997). Another research by Amiri-Khorasani et al. (2010) concluded that to achieve high kinematic reactions related to stretch shortening cycle (SSC), 5 successive kicks are adequate due to it implies the well optimal coordination segmental pattern and production of force resultant from SSC. The result began to decline and inconsistent when attempted the next trial.

Following the BST, the point of hinge of joints were determined and after cleaning the skin, the markers were placed on the femur lateral epicondyle, lateral malleolus and the distal head of fifth metatarsal (Dorge et al., 2002). Since all the participants choose to kick the ball using their dominant leg, therefore, the supporting leg was considered the other side of the leg. Prior to the test, all the participants had been reminded to kick a stationary ball with only one approaching step. Data had been recorded as video at 120 fps with 500 shutter speed by one video camera (C1) which is high speed camera (CASIO EX-ZR1500, Japan). The testing for maximum instep kick was set up as shown in Figure 2.

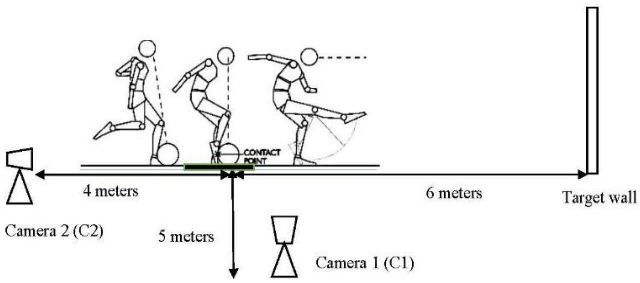

Figure 2: Maximum Instep Kick Test set up.

Figure 3: Posterior view of camera 2 for detection of the ball accuracy.

Participants were restricted to execute the kick by only one step of maximum instep kicking to avoid an obvious error occur in the frontal plane. Participants had to make straight step up from a ready position right behind the ball at an approach angle of 0º to 35º (self-selected) on the special customize kicking wooden deck [1.2192 meters (width) x 2.4384 (length)]. Futsal ball size 4, FIFA's approved with weight of not less than 400 grams and not more than 440 grams, pressure at 400 – 600g/cm2, and made of leather was used for each kicking session, and its inflation was controlled throughout the trials and kept at 500 kPa. The results were recorded into a data table according to it class of variable for each participant trials.

C1 was positioned laterally 5 meters away, 0.7 meter of focus point height, directed perpendicular to the sagittal plane of the participant movement path and parallel to the medio-lateral axis as their kicking leg giving approximately a 90º between their respective optical axes (Ahsan & Ruru, 2014). The view of recording was calibrated about [one meter (height) x one meter (width) x one meter (length)] due to recording of the kicking movement too close and it was done in order to minimize view error (Abdel-Aziz & Karara, 1971). One meter ruler was used as a calibration mark. Another (C2) video camera (SONY CX-900 HDVC, Japan) was positioned 10 meters away from the kicking wall target with posterior view of participant. This camera was used to record the ball accuracy when the ball hit the target, and was set at the focus view of the bull eye target.

When the participant was ready, the tester gave a verbal, instruction "ready…GO" which means they are 100% ready and "GO" means starting the movement to execute the MIKT. The button start for the recording data had been clicked simultaneously with the sound signal of "GO" and the button stop of recording data had been clicked when the participant completed his follow-through.

Supporting leg strength had been evaluated from the data measurement, provided from the force platform analysis. Every each participant had undergone 3 trials for maximal instep kick without target 3 trials for maximal instep kick with target. The participant had to move the body forward by one-step-approach towards the placed ball, and plant their supporting leg on top of the force platform, just beside the ball, at the same time flex the hamstring and the knee joint of kicking leg in so as to get the best angle for maximum foot velocity and a kick was made by extending the hamstring of their kicking leg with the right foot to ball contact point. In order to get maximum impact of foot to ball contact, the point of contact had to comply with Figure 2 given.

Every participant had to complete all the sequential phases of segmental movement in kicking started from approach step and completed with follow through. While, during executed MIKT with target, participants had to focus their kicking magnitude towards the wall target. The wall target had been labelled with the point according to the bull's-eye colour. The bull's-eye target made from flex 0.42mm, size (4 feet x 4 feet), with different colour according to the area target and 0.45 meter height from the floor. The highest score region is in the centre of the bull's-eye. 5 points had been given when the ball hit the centre of the bull's-eye, followed by yellow area (4 points), red area (3 points), black area (2 points) and white area (1 point) (see Figure 3).

Data Analysis

Data analysis for this research started with the collection of the anthropometrics profiles for every participant. The anthropometrics profile had consists of participant age, body weight, height and BMI. The data was managed using the Excel 2013 (Microsoft Limited, UK). Two tests had been completed by participants and it had produced an essential data for further analysis. Every participant has to execute the BST which produced the average velocity and 95% ellipse area results for static balance of supporting leg. While, dynamic balance of supporting leg results was produced by AMTI Acquisition Software version 3.05.00 during the execution of MIKT. During MIKT, the Maximal Vertical Force (MVF) also was recorded and only the maximum reading for each trial of MIKT was identified. The means of maximum score for 3 trials had been calculated and identified according to kicking without target and kicking with target for further analysis. Meanwhile, the data of kicking performance was taken from the video analysis results by using the KINOVEA® motion analysis software (free version) as in Figure 4.

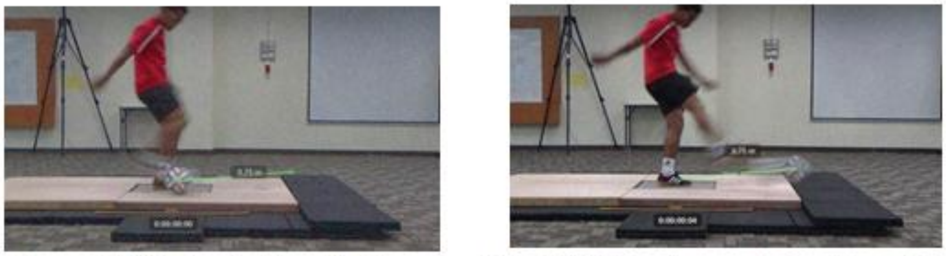

Figure 4: Ball velocity identification using KINOVEA® motion analysis software (free version) during instep kick (original example).

Formula,

$$v = \frac{\Delta D}{\Delta t} \quad (1) \qquad and \qquad \frac{\Delta D}{\Delta t} = \frac{Dn - D_{n-1}}{t_n - t_{n-1}} \quad (2)$$

As shown in Figure 4, some plots had been made and the calculation as above formulas had been used to determine the ball velocity of every trial for every participant. The video had been processed frame by frame at 0.004 frame per seconds. Then, the results were classified into the two categories either kick without target or with target.

From video recordings (C2), the data for ball accuracy for instep kick were identified. The video recordings assists the tester in ensuring the point given to every single kicking trial is absolutely correct and triangulated.

Statistical Analyses

Statistical analysis had been done using Statistical Package for the Social Science (SPSS) Software (IBM Corp version 22.0.0). Only data of the mean values of the 3 trials had been used for further inferential analysis. Data was checked and screened for normal distribution using the Kolmogorov-Smirnov and Skewness-Kurtosis. Data was considered normally distributed when the Skewness-Kurtosis values showed a range between ± 1.96. This results had been summarized using descriptive statistics. All data were expressed as mean ± standard deviation (SD).

To verify whether measurements between the two set of variables was valid, paired sample t-test were used. The level of significance was set at $p<0.05$. The evaluation of the relationship between two values of the parameters had used Pearson's correlation coefficient calculation. The level of significance, r value was set at $p<0.05$. Determination of correlation coefficient for r values (a value between -1 and +1) was followed as weak relation for $r = \pm 0.0$ to 0.3, intermediate relation for $r = \pm 0.31$ to 0.7 and strong relation for $r = \pm 0.71$ to 1.0 (Rumsey, 2011). Squaring r value makes then easier to understand where 0.5 means 25% of the variation is related (.5 squared =.25).

Results

Table 1: Independent variables and dependent variables.

Types of Variables	Variables	Parameters	(mean ± standard deviation)
Independent Variables	Supporting leg strength	Maximal vertical force - with target (N)	1389.68 ± 186.81
		Maximal vertical force - without target (N)	1531.50 ± 220.62
	Supporting leg balance (static)	Balance Stork Test - 95% ellipse area (cm^2)	10.52 ± 3.79
	Supporting leg balance (dynamic)	Stance time (with target) (sec.)	0.379 ± 0.150
		Stance time (without target) (sec.)	0.349 ± 0.102
Dependent Variables	Kicking performance	Ball velocity - with target (ms^{-1})	18.329 ± 2.347
		Ball velocity - without target (ms^{-1})	19.407 ± 2.497
		Ball accuracy (Point)	2.921 ± 0.877

Table 2: Correlation analysis results.

Variables	Sig. (Pearson-r)
Maximal vertical force – Without target (N) with Stork Test - 95% ellipse area (cm^2)	- 0.071
Maximal vertical force - with target (N) with Ball velocity - with target (ms^{-1})	0.336
Maximal vertical force - without target (N) with Ball velocity - without target (ms^{-1})	0.214
Balance Stork Test - 95% ellipse area (cm^2) with Ball velocity - with target (ms^{-1})	0.109
Balance Stork Test - 95% ellipse area (cm^2) with	0.091

Ball velocity - without target (ms^{-1})	
Maximal vertical force - with target (N) With Ball Accuracy (point)	- 0.361*
Balance Stork Test - 95% ellipse area (cm^2) With Ball Accuracy (point)	- 0.095
Ball Accuracy (point) With Stance time (with target) (sec.)	- 0.083
Ball Accuracy (point) With Stance time (without target) (sec.)	- 0.071

* Significant correlation

Discussion

The main purpose of this study is to analyse the relationship between the role of supporting leg strength and balance toward kicking performance. This area of study has summarized the total results of all variables and reported the factor lead to the maximal instep kick outcomes.

Correlational results

The results of this study showed that no significance correlation among supporting leg strength and supporting leg balance, supporting leg strength (with target) and ball velocity (with target), supporting leg strength (without target) and ball velocity (without target), supporting leg balance and ball velocity (with target), supporting leg balance and ball velocity (without target), supporting leg balance and ball accuracy, Stance time (with target) and ball accuracy, stance time (without target) and ball accuracy. However, supporting leg strength (with target) showed negative correlation with the ball accuracy (see table 2).

Factors that lead to insignificant result

This study agreed with the statement of supporting leg permits the body to support and stabilize the momentum produced by the leg of kicking. Supporting leg also form the technical position of the hip and permitting the rotation to occur together with the upper part of kicking foot (Barrett & Bilisko, 1995; Orchard et al., 1999). A firm supporting leg produce flexion and extension of muscles to support the push force (GRF) and transfer the force through segmental muscle coordination. However, this study found that the kicking performance was not significantly influenced by the role of supporting leg.

One of the factor affected this result is due to the reduction on the angular and linear velocity of the kicking leg and this situation was similar to the research done by Nunome et al. (2002). Through observation, participants obviously reduced their kicking speed when executed the maximum instep kicking with and without target. This situation caused the ball velocity for kicking with target is just slightly lower than kicking without target (see table 1). However, supporting leg push force reduced by a whisker due to contextual interference adjustment (reaction of sensorimotor to spatial and temporal factors) and not significantly affected the ball velocity.

Participants seems preferred to slow down the kicking leg speed and caused less supporting leg pressure when the ankle rigidity was reduced (Ismail et al., 2014). This situation occurred due to two principles which are perceptual motor learning system and the degree of freedom.

The execution of maximal instep kick is one of the movement concepts where both aspects of maturation and experience involved (Gallahue & Donnelly, 2003). Adaptation to the environment through sensory sensitivity requires participants to refine spatial and temporal world (Gallahue & Donnelly, 2003). Participants need to move according to the perceptual motor process which involved the sensory output, sensory integration, motor interpretation and movement activation.

Restriction to one step approach and limited angle of space during kicking potentially which act as the affected factor to the results. The degree of freedom arises when a complex system needs to be organized in order to produce a specific result (Barbieri et al., 2010). The kicking result was appeared as similar between trials and two conditions when the participant did the test using the closed loop control system as they react to the contextual interference (limited step, angle, ball trajectory and bull eye target) (Barbieri et al., 2010). Participants tend to reduce the ankle rigidity for both kicking with and without target.

Through study observation, participant used to strategizing their kick and tried to react to the wall that they focus to hit (closed loop) rather than ignoring the wall. Supporting leg strength was not the caused factor in enhancing the kicking performance, such as ball velocity, however, this force is just to maintain the body balance and help in sequential of body coordination during executing the kick in order to maintain stability.

Although supporting leg balance is important in maintaining body coordination during kicking movement, however, the result showed that, there is no significance relationship between supporting leg balance with ball velocity and with ball accuracy at ($r = 0.091$, $p > 0.05$) and ($r = 0.901$, $p > 0.05$) accordingly (see table 2). This indicated that supporting leg balance (static balance) did not influence the ball velocity during the kick. Table 2 also showed that no significance relationship occurred between supporting leg strength and supporting leg balance at ($r = -0.071$, $p > 0.05$).

The result also shown no significant correlation among the dynamic balance of supporting leg and ball accuracy between both kicking condition (with target and without target) toward ball accuracy (see table 2). The result indicated that stance time for kicking with target is slightly longer than kicking without target and also longer than previous findings by Ahsan & Ruru (2014). They recorded the time period for stance time phase is about 0.13 to 0.15 seconds. Participants allowed their supporting leg to have more time in stabilizing the position during performing the kick (Lees et al., 2009).

Chew-Bullock et al., (2012) found that balance on the single leg was considerably related with kicking accurateness, nevertheless not to velocity. In addition, it occurred due to different level of skill among the participant that had different ability in single leg balance. Meanwhile, this study used the same participant in testing which lead to have no significant result in relationship between supporting leg balance and ball accuracy or ball velocity.

Participants are able to control and balance their single leg stance for 60 seconds and their 95% ellipse area is almost consistent.

Factors that lead to significant result

Ball accuracy is one of the indicators to identify the excellent player and excellent kicking performance in futsal. This research had found that supporting leg strength (max-vGRF) is significantly correlated with the ball accuracy.

The relationship between supporting leg strength and ball accuracy (see table 2) showed significance correlation exist at ($r = -0.0361^*$, $p < 0.05$). This result also showed negative correlation of the magnitude. This value indicated that, when the participant did the maximal instep kicking to the bull eye target, they tend to slow down the velocity of the foot in order to ensure the swing of the kicking leg to strike the ball has the best contact area to the ball with greater impact. This movement caused the supporting leg to reduce the impact force and then max-vGRF found slightly decreased.

This situation was related to the Dynamic Dominance Model of Motor Lateralization. This model was introduced by Sainburg & Wang, (2007) and Sainburg et al., (2009). This model proposed that each cerebral hemisphere/limb system becomes specific for handling different motor task. The right leg/left hemisphere system would be specific for trajectory or impact control and left/right hemisphere system act on stability control in supporting leg. In order to control the stability, rigidity of the ankle was less and max-vGRF on supporting leg decreased, therefore, significant correlation between max-vGRF and ball accuracy occurred.

Moreover, the distance targets probably not enough for identified the Magnus effect of ball flight (Shinkai et al., 2009). Therefore kicking accuracy is more precision and lead to has significant relationship with the max-vGRF result.

Reduction on approaching speed also was effected ball accuracy and lead to significant result. This situation was also reported in the research by (Andersen & Dorge, 2011; Ismail et al., 2010; Kellis et al., 2004). Participant seem to slightly control their movement in planting the supporting leg in order to stabilize the movement for foot to ball contact accuracy. Thus, supporting leg push force had reduced due to the low impact of supporting leg planting.

However, a clear statement was stated that during kicking with target (accuracy), control of movement is considered as the restraints of specific performance context. Therefore stability of self-preferred approach speed during the kicking and energy transferred to hit the ball had reduced with accordance to the presence of specific performance context (Orth et al., 2012) which is the involvement of contextual interference during the kicking.

Conclusion

Supporting leg strength (max-vGRF) is not the caused factor in reduction of kicking leg velocity (see table 2) and also not the premier assistant for increasing ball velocity. Previous findings by Masuda et al., (2005) also did not found any significant correlation between supporting leg strength and ball velocity.

Previously, a number of studies found that the average ball velocities of the instep kick is around 20.14 ± 1.58 ms^{-1} (Isokawa & Lees, 1988) and 20.41 ± 2.44 ms^{-1} (Kellis et al., 2004). However, this study found that the average ball velocity was 19.407 ± 2.497 ms^{-1} slightly lower on the value is due to level of skill of participants (recreational player). Studies on elite field soccer players was found that soccer practice has important influence on balance ability (Ghahramani et al., 2011; Barone et al., 2010; Gioftsidou et al., 2006; Suncan et al., 2005) and it is believed that the physiological adaptation which provides balance is improved more in futsal players. However, this study was identified no significant relationship with kicking performance due to level of skill of futsal recreational player.

Masuda et al., (2005) found that strength of the supporting leg is related with velocity of the ball during kicking from a huge angle of approaching (i.e. an approach angle of 135º). Masuda et al., (2005) proposed that highly strength on hip extensor, knee flexor, and hip abductor was essential to sustain the body stability throughout an off balance kick and to produce highly velocity of the ball.

Nevertheless, this research finding was shown that maximum ball velocity achieved by participant in this study is 25.58 ms^{-1} which for kicking without target and 25 ms^{-1} for kicking with target. It was by a whisker decreased during maximal instep kick with target but it does not show any profound difference. In conjunction with that, this is possibly due to near of distance target and maximum effort of kicking selected. The distance between place ball and target usually affect the characteristic of the ball flight (Shinkai et al., 2009). If this research had used more distance between ball placing and the target and a variety of kicking speed, the results may possibly be different, as participants desire to have a better kick in ball velocity and concurrently they try to balance the movement in order to control the accuracy. Ismail et al., (2014) found that for the period of kick with moderate effort, futsal players had reduced plantar flex movement about the ankle-foot joint, therefore resulting in lower ankle-foot velocity. This statement had been supported by Sterzing and Hennig (2008).

In particular, limitation of this study which has not focus on the angle of knee extension during plantar flexion start to react is one of the important aspects that should be the focus for future study. This study expected that stretch shortening cycle would provide greater elastic energy to the supporting leg during the kicking.

Thus, if this aspect of positioning centre of gravity had been explored, possibility to relate the influence of supporting leg as assisting factor for better kick performance might be exist.

According to Cerrah et al., (2011) professional players kick with a higher ball velocity compared with amateurs might be due to weaker hamstrings and due subtle differences in their techniques during kicking movement.

Recreational players have less training experience in comparison with professionals and this situation possibly affect muscular coordination and balance. Thus, it may impair directly on the quality of kicking technique performed.

Continuity on practicing skill for a period of time will increase level of task performance (Ericsson et al., 1993) and it's also depend on how individual response to contextual interference effect (Ollis et al., 2005).

It was not possible to compare the results found in this study with those of previous studies because no other similar studies on futsal can be found at this moment, with some exception on few studies in soccer. As stated earlier, the role of supporting leg strength and supporting leg balance were not directly related in influencing the ball velocity during the kicking. However, without these functions of supporting leg, the maximal instep kick movement cannot be well implemented and effectively coordinated.

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