THE INFLUENCE OF STRENGTH AND BALANCE OF SUPPORTING LEG DURING MAXIMAL INSTEP KICK ON KICKING PERFORMANCE

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ABSTRACT

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 Test (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 hundred and twenty frame per second, with five hundred hertz shuttle 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 (max-vGRF) or supporting leg balance (95% ellipse area).

PENGARUH KEKUATAN DAN KESEIMBANGAN KAKI SOKONGAN SEMASA SEPAKAN MAKSIMUM KEKURA KAKI TERHADAP PRESTASI SEPAKAN.

ABSTRAK

Kajian ini bertujuan untuk menentukan hubungan antara kekuatan dan keseimbangan kaki sokongan; dan menentukan korelasi terhadap prestasi sepakan (halaju bola dan ketepatan bola). Tiga puluh empat orang pemain futsal rekreasi UPSI lelaki telah mengambil bahagian dalam kajian ini. Ciri-ciri fizikal seperti umur, berat badan, ketinggian dan indeks jisim badan peserta kajian direkodkan. Platform daya telah digunakan untuk mengukur pembolehubah kinetik semasa ujian tendangan kekura kaki maksima (tanpa sasaran dan dengan sasaran) serta "Balance Stork Test". Kamera video berkelajuan tinggi ditetapkan pada seratus dua puluh bingkai sesaat dan "shutter speed" lima ratus hertz telah digunakan untuk mengimbas kedudukan imej bola selepas sentuhan kaki ke bola bagi mengenalpasti halaju bola. Pengiraan halaju bola diperolehi dengan bantuan penggunaan perisian analysis pergerakan. Pearson korelasi digunakan bagi tujuan menganalisis hubungan antara semua pembolehubah. Kajian ini mendapati bahawa tiada apa-apa hubungan yang signifikan antara daya maksimum menegak (max-vGRF) dan halaju bola untuk kedua-dua sepakan, antara "max-vGRF" dan keseimbangan kaki sokongan, antara keseimbangan kaki sokongan dan halaju bola, antara keseimbangan kaki sokongan dan ketepatan bola. Walaubagaimanapun, hubungan signifikan yang negatif wujud antara "max-vGRF" dan ketepatan bola. "Max-vGRF" dan halaju bola untuk kedua-dua tendangan tanpa sasaran dan tendangan dengan sasaran menunjukkan korelasi yang tinggi. Kesimpulannya, faktor sama ada kekuatan (max-vGRF) atau keseimbangan (95% ellipse area) kaki sokongan adalah bukan merupakan faktor utama dalam menentukan hasil prestasi sepakan.

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LIST OF ABBREVIATIONS

2D	Two dimensional view
3D	Three dimensional view
BMI	Body Mass Index
BST	Balance Stork Test
CM	central of mass
COP	Centre of Pressure
EMG	Electromyography
EMS	electro-stimulation
fps	frame per second
GRF	Ground Reaction Force
Hz	hertz
kg	kilogram
kgf	kilogram-force
m	meter
MHF	Maximum Horizontal Force
MIKT	Maximal Instep Kicking Test
mph	miles per hour
ms^{-1}	meter per seconds
MVF	Maximum Vertical Force
N	Newton
RTD	Rate of Torque Development
s	seconds

SD	standard deviation
SSC	stretch shortening cycle
TTS	Time to Stabilization
UPSI	Universiti Pendidikan Sultan Idris
UPST	Uni-pedal Stand Test
VO_2max	maximum oxygen consumption

CHAPTER 1

INTRODUCTION

1.1 Background of Research

Soccer is one of the best widespread sports, exceeding 200 million people had involved playing it worldwide, and it has the uppermost rate of involvement around the world (Emery, Meeuwisse & McAllister, 2006; Emery, Meeuwisse, & Hartmann, 2005; Junge, Rosch, Peterson, Graf-Baumann & Dvorak, 2002). Generally, it is known that soccer is a contact game that is tremendously popular in numerous states (Sterzing, Muller & Milani, 2010; Stolen, Chamari, Castagna & Wisloff, 2005; Masuda, Kikuhara, Demura, Katsuta & Yamanaka, 2005). Irrespective of one's age and sex; old or young, male or female (Naghme & Heydar, 2010), they like to play all kind of soccer and in the meantime it is challenging due to its fast motion such as dribbling, attacking, dramatic and dynamic game. The famous game as soccer was not only being play

outdoor, however, one collective version of the soccer had been introduced and it's known as indoor soccer (Ahsan & Ruru, 2014). The increasing of demand in the game of indoor soccer had drag the game to become more recognized (Roxburgh, 2008).

The game known as indoor soccer started since 1933, where once Juan Carlos Ceriani Gravier, professor from ACM Montevideo request his college learners to perform soccer using the basketball court or hockey ground (Polidoro, Bianchi, Di-Tore & Raiola, 2013). His objective was to create a team sport practicable for indoor and outdoor facilities, utilizing existing a great number of basketball courts which could be similar to soccer that was very famous since long time ago. Regarding to this, the indoor soccer had been played by five a side due to a scaled down in pitch size.

Uruguay was the origin for "five a side soccer", where it was conventionally recognized as "Futbol de salon" (Polidoro et al., 2013). At the international level, it is known as futsal where the Portuguese usually named it "fut'saw". The name was derived from combination of the Portuguese "futebol de salão", which can be interpreted as "hall football" or "indoor football".

Futsal is the only form of indoor soccer which endorsed by Football International Federation Association-FIFA (2008) since 1980s with over sixty countries involved professionally in the game. Futsal is derives from version of soccer and was used as the starting ground in developing skills. According to Naghme & Heydar (2010), the game of futsal is modified from the field soccer and have the same characteristic in dribbling of a ball. The nature of futsal is quite similar to the field soccer which involve the same movement in doing a kick, the types of kick and most

of the time used lower limb in the game (Huang, Lu & Wu, 2013). The exclusivity of using the feet to hold, dribble, and kick the ball almost all the time is the tremendous technique in futsal (Polidoro et al., 2013).

Since futsal is similar to the conventional soccer, kicking is one of the primary essential ability for the player during a match or training (Barfield, Kirkendall & Yu, 2002; Lees & Nolan, 1998) and development of kicking technique should be initiated at early stage of age (Weineck, 1997). Ismail, Adnan & Sulaiman (2014) noticed that variability of kicking ability is essential for futsal player to execute a well-adjusted combination of lower rate, medium and maximum effort of kicking all over the match or training. Numerous technique of kicking had been introduced such as instep kick, front kick, inside-foot kick, outer foot kick and back heel kick. These kind of kicks had been used according to the constraints in the match (Williams, Davids & Williams, 1999; Newell, 1986). The constraints that futsal players need to accommodate is by moving in limited space due to the small size of the futsal court compared to field soccer (Cowden & Torrey, 2007).

In conjunction with the limited space and small size of the goal, therefore, the suitable choice of kicking is very important especially during shooting the goal. The choose of maximal instep kick is the best choice due to its ability in producing highly rate of ball velocity (Nunome, Lake, Georgakis & Stergioulas, 2006; Apriantono, Nunome, Ikegami & Sano, 2006; Lees & Nolan, 1998) and was very regularly used for penalty (Scurr & Hall, 2009). Kicking with the high velocity of the ball possibly will past over the goalkeeper (Kellis & Ketis, 2007) and straight trajectory to the target.

However, it is not only kick with high ball velocity, the aspect of accuracy also play an important role as indication of playing abilities (Scurr & Hall, 2009) and during shooting in futsal, player has to execute the kick very quickly and accurately. The accurateness and precision of kicking is an essential component of skills in futsal. Definition for precision had defined as the capability to kick the ball toward a definite bull's eye (Scurr & Hall, 2009). Player has to be able to kick with high ball velocity and accuracy in order to increase the chance to score the goal. To produce these kind of high ball velocity and accuracy, there are some assistance factors that were contributed in increasing the ball velocity and accuracy.

One of the potential factor that rarely discuss on the influence of increasing ball velocity and accuracy is the role of supporting leg. Supporting leg had been described in previous research which some findings found that beneficial and significantly assisting the kick (Shan & Westerhoff, 2005; Barfield, 1998). Some findings found the other way around (Kellis & Ketis, 2010) and the results of GRF is obtained from correlation between two types of kicking. However, the supporting leg still seem to act as the arc strength for the body to execute the kick (Inoue, Nunome, Sterzing, Shinkai & Ikegami, 2012; Shan & Westerhoff, 2005). Basically, it is known that human should possess muscular strength in initiating a movement, but in the movement to implement a kick, players should integrate and coordinate a large number of muscles to achieve the best technique of kicking (Nunome et al., 2006; Coburn, Housh, Cramer, Weir, Miller, Beck, Malek & Johnson, 2005).

This complex process of kicking was done through bilateral lower limb movement in the sagittal plane which start with planting the supporting leg on the

ground by extending the knee joint and allow the kicking leg to swing and hit the ball. This action caused the third law of Newton's which is action and reaction principle to be occurred. Supporting leg that was planted to the ground will allow the vertical ground reaction force to transfer the energy through segmental body and coordinating the greater swing of kicking leg. Therefore, supporting leg has to be strength enough in order to increase the kicking leg speed and produce high ball velocity or accuracy. An amount of strength training exercises to the supporting leg will enable the aid in developing the kicking power so as to increase the leg speed (Masuda et al., 2005).

Increasing in supporting leg strength also will effect in promoting joint ability and balance (Dennis Valdez, 2003). Excellent muscle strength on supporting leg had produced more muscles recruitment and a lot of contraction provide good support to the joint during kicking. Thus, player who has excellent in muscular leg strength had always greater in supporting leg balance (Noguchi, Demura & Nagasawa, 2012; Nunome et al., 2006) and greater in supporting leg balance had led to the greater stage of skill capability (Evangelos et al., 2012). The state of supporting leg balance are depend on comprehensive reaction that commenced by three major sensory system (Gstöttner, Neher, Scholtz, Millonig, Lembert & Raschner, 2009) and it always change according to the present of the contextual interference during execute a kick. Balance ability on supporting leg is essential in stabilizing the body at its best supporting position at the moment of planting the foot (Kawabata, Demura & Uchiyama, 2013; Lees, Steward, Rahnama & Barton, 2009).

Although some previous research had discuss on the supporting leg (Inoue, Nunome , Sterzing, Shinkai & Ikegami, 2014; Inoue et al., 2012; Kellis & Ketis 2010;

Masuda et al., 2005), however there are still gap in explaining the actual role of supporting leg strength and balance towards the ball velocity and accuracy.

Through the review, the study conducted in the aspect of supporting leg role during kicking in futsal rarely found (Moore, Bullough, Goldsmith & Edmondson, 2014) and yet still there are contradictions on findings in soccer (Kellis & Ketis, 2010; Shan & Westerhoff, 2005; Barfield, 1998). The influence of supporting leg had received little interest in the research literature. Although the research by Dichiera, Webster, Kuilboer, Morris, Bach & Feller (2006) had found that players have additional flexion on the thigh in the kicking as well as in the supporting leg, throughout the completion the kick. However their findings was not stated on kinetics relationship of the supporting leg and kicking performance.

As a result, new features of identifying kick performance will be explored in this research. Thus, this research will uncover the influence of supporting leg strength and supporting leg balance in developing ball velocity and ball accuracy during a kick. In addition, Lees, Asai, Andersen, Nunome & Sterzing (2010) found that no current research had described the results of the supporting leg, although it is known to be essential to the instep kick production. Beside the research mentioned, there are possibly some studies that had been conducted on identifying the supporting leg mechanics and kinematics.

This research was conducted by using the quantitative approach and more precisely is correlational method. There are two main purposes of this research which first is to determine the relationship of supporting leg strength and supporting leg

balance. The second purpose is to investigate the relationship both of the supporting leg strength and supporting leg balance towards the kicking performance. All the participant in this research had gone through two types of tests which are Balance Stork Test (BST) and Maximal Instep Kick Test (MIKT). This research had been focused on maximal vertical ground reaction force as represent as data for supporting leg strength. The 95% ellipse area of BST and stance time during the MIKT were represented as the data for supporting leg balance. While, data of kicking performance are consists of the ball velocity and ball accuracy. This data is classified as the dependent variables.

1.2 Problem Statement

Futsal had begun to be recognize in all corners of the world (Moore et al., 2014). The rapid growth of futsal arena in Malaysia indicated that it is getting popular among Malaysian. Nowadays, a lot of people are interested to be involve in this game as it seem to be quite convenient to play in an indoor court especially during bad weather (Duarte, Batalha, Folgado & Sampaio, 2009; Esteban, Inaki, Javier, Cristina, Ion, Maite, Henry & Mikel, 2009).

Regarding to the fast development in a game of futsal, there are a few researches had been studied in such area of interest in futsal. Some researches had been conducted to search physical demand for futsal (Esteban et al., 2009), passing action throughout the futsal game (Travassos , Araujo, Duarte & Mc.Garry, 2012), kinematics of kicking (Barbieri, Gobbi, Santiago, & Cunha, 2010) and different effort in futsal kick (Ismail et al., 2014). Previous researches mostly discovered and focus on the biomedical

aspects (Serrano, Shahidian, Sampaio & Leite, 2013; Ribeiro & Costa, 2006). Very limited research on aspects of games analysis (Ren, 2013; Travassos et al., 2012) and physiological need of the futsal game (Castagna, D'ottavio, Vera, Álvarez & Barbero, 2009; Álvarez, D'ottavio, Vera & Castagna, 2009). In addition, research on determining the relationship between the supporting leg strength and balance towards the kicking performance in futsal was not reported yet.

The result of the studies was being used to help in player practice (Bases, 2008). However, there are very limited findings on futsal even more so if this game had compared to the game it originated, soccer (Amaral & Garganta, 2005). Some reviewed on the kinetics and kinematics of kicking in futsal had been done and as a result, there are very limited findings. Probably this situation occurred because of the similarity that existed between characteristic of kicking in futsal and kicking in soccer.

Although the previous research findings on kicking in soccer had been used as reference for futsal, however, there are still unresolved problem existed in determining the best approach of improving the kicking performance in soccer. Thus, this situation would affect the kicking performance in futsal too when this issue of kicking had been discussed further.

As rapid grow of the futsal game among countries, some beneficial findings which is able to support for the improvement of playing of the game is very important. Kicking is the initiated movement in the futsal game and the team which achieves extra effective kicks at the focusing aim (shooting) is more possible to earn victory in the

match (Kellis & Ketis, 2007). In order to maintain and increasing the effective shooting, the team has to strategies all of the movement in the game by considering a few aspects.

Morato (2004) found the strategy by dividing the futsal game into six elements consist of execution the same ball, area or space covered, opponents, teammate, goal attack and defend by following all rules. These elements are also implied in other sports such as field soccer, handball, water polo, hockey, rugby and basketball. Attacking is one of the consideration of operational target in futsal and it is very important to emphasize at the ending of attacking, which is kicking toward the goal or sometimes called "shooting" (Werlayne, 2012; Irokawa, Lima, Soares, Aburachid, Souza & Greco, 2010). Dynamic movement in futsal such as shooting, should be studied on its unusual potential factors that can enhance performance (Santana & Garcia, 2007). However, the study only concerned on kicking offensively during the futsal game (Werlayne, 2012). Study on shooting in futsal is rarely found and this research had been conducted to study the shooting kick among futsal recreational players. This study also had been focused on the relationship between shooting without target and shooting with target.

During the futsal game, implementing the shooting is not just a simple kick, however it had been required specific ability in determining the shooting. Since size of the futsal goal is smaller compare to soccer and being played in limited area due to small size of pitch, the maximal instep kick had been chosen due to its ability in producing greater ball velocity toward target and quick to perform (Barfield et al., 2002). The ball has to pass the goal keeper without enough time for him to intercept.

In addition, high in ball velocity as maximal instep kick production is always caused the ball flight in straight trajectory and minimum in Magnus effect (Shinkai, Nunome, Ikegami & Isokawa, 2008). It mean that the maximal instep kick had also promoting the accuracy of the ball to hit the target. Thus, regarding to this situation, this research had used the maximal instep kick as the testing tool in order to translate the best choice for shooting in futsal.

Although aspect of kicking style is critical to the expression of greater kicking leg swing, most investigation of kicking had focused on the kicking leg, with few examining the influence of the support leg in facilitating effective and efficient kicking movement. Previously, some studies discovered the maximal instep kick on the aspect of kinematics. Kinematics study on the maximal instep kick usually focus on the behavioural of the kicking leg (Nunome et al., 2006). However, limited research had been conducted on the supporting leg. Most of the test that conducted on kicking had intensively focused on the leg performing the kick, but study done on supporting leg are rare, especially, which involved the futsal player (Sidaway, Anderson & Matthew, 2007).

Thus, this research had focused on the influence of supporting leg during maximal instep kicking. Supporting leg is the opposite of the kicking leg which had planted to the ground before the hip and knee joint start to extend during the leg swing. This supporting leg is play a role as support limb for body to move during performing the kick. The knee flexion had been initiated at the moment the leg is planted, which allows the vertical force production on the supporting leg and effectively transfer the force to the segmental body movement in gaining the ball velocity and trajectory

(Baktash, Hy, Muir, Walton & Zhang, 2009; Sterzing & Hennig, 2008; Orloff, Sumida, Chow, Habibi, Fujino & Kramer, 2008; Kellis, Ketis & Gissis, 2004). A few research found that successful kick was not just depend on the kicking leg, however the influence of supporting leg had been contributed in enhancing the kicking performance (Inoue et al., 2012; Shan & Westerhoff, 2005). Regarding to the important of supporting leg in kicking, thus, this research had focused on two independent variables which is the supporting leg strength and the supporting leg balance.

The role of supporting leg in influencing the kicking performance had through it strength and balance ability. However, the potential strength on supporting leg related to shooting in futsal had not been clearly stated (Moore et al., 2014). Research by Esteban et al., (2009) reported that shooting in futsal requires substantial strength level to perform by the kicking leg and never mention about supporting leg strength.

Nunome, Shinkai & Ikegami, (2012); Kellis & Ketis (2007); Masuda et al. (2005) study the effect of supporting leg strength on ball velocity among skilled soccer players and they found that no significant relationship between supporting leg strength and ball velocity. Helgerud, Engen, Wisloff & Hoff (2001); Commetti, Maffiuletti, Pousson, Chatard & Maftulli (2001) found that kicking leg strength is not the factor in determining the ball velocity. It was indicated that greater strength on the kicking leg was also not able to produce greater changes in ball velocity. The others factor such as supporting leg strength need to be focus too and it was seem that it has significantly potential in promoting excellent kicking performance. Inoue et al., (2014; 2012) reported that supporting leg play an important role in accelerating the kicking leg swing