LEG DYNAMIC STRENGTH PREDICTORS OF A PRE-PLANNED CHANGE OF DIRECTION TASK IN NCAA DIVISION I SOCCER PLAYERS

Chieh-Ying Chiang, Christopher A. Bailey, Christopher J. Sole, Timothy J. Suchomel, Kimitake Sato, and Michael H. Stone

East Tennessee State University, Johnson City, TN, USA

The purpose of this investigation was to evaluate the relationships between two types of vertical jumps and change of direction (COD) test in collegiate soccer players (n=24). 5-5 COD test was utilized to measure soccer athletes' COD ability. 3m acceleration (3mAcc), Total time (TT) and Partial time (PT) were measured by two sets of timing gates. Countermovement jump (CMJ) and static jump (SJ) with 2 different loading conditionings (0kg and 20kg) were employed to evaluate athletes' leg dynamic strength. Strong statistically significant relationships were found between COD test variables (r =0.71 to 0.90), and between vertical jump variables with PT and TT (r = -0.41 to -0.81). These results suggest that leg dynamic strength is vital for NCAA Division I soccer players' COD performance and SJ 0kg jump height can be used to predict for COD performance.

KEYWORDS: agility, change of direction ability, vertical jump, soccer

INTRODUCTION: Agility has been proposed as the ability to rapidly sprint and change of direction while also responding to outside stimuli (Sheppard & Young, 2006). Typically, agility movements in field sports (soccer, rugby) and court sports (basketball, volleyball) involve accelerating short distance (<10m), decelerating according to a stimulus (balls, opponents' defense, executing tactical strategies) and then changing toward a new direction. More recently, two major components of agility, which are COD ability and perceptual, decision-making have been proposed as key limiting factors for athletes' agility performance (Spiteri et al., 2013). In addition, for those movements and tests that require athletes to finish a COD task without though processing, and for which athletes apparently know the paths they will complete before performing, have been defined as COD ability and pre-planned COD test, respectively (Spiteri et al., 2013).

COD ability is important for team sport athletes' success, especially soccer (Chaouachi et al., 2012). However, there is little evidence relating the association of COD and leg dynamic strength in collegiate soccer players. Although strong correlations between maximal strength, power, sprint and jump abilities in soccer players have been reported by different authors (Castillo-Rodríguez et al., 2012; Chaouachi et al., 2012; Stolen et al., 2005; Vescovi & McGuigan, 2008; Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004), the interactions between strength characteristics and COD ability, remains unclear.

Recently, the research focus of agility studies has shifted toward a topic that deals with the relation of athletes' decision-making process of sport-specific stimulus (Serpell, Youg, & Ford, 2011). A relative small number of studies have examined leg strength qualities and COD performance, especially those including soccer athletes (Vescovi & McGuigan, 2008).

The use of diverse muscular strength and power tests for team sport athletes has become an increasing focus of study in sport science communities. For example, Baker and Newton (2008) evaluated 40 national-level rugby players by testing lower body strength, power, acceleration, maximal speed and COD ability. Their results illustrated that squat jump power could differentiate first division and second division players and their agility performance. Similar findings have also published by Barnes et al. (2007). Superior vertical jump height was shown in NCAA Division I female volleyball players when compared to Division II and Division III levels. Therefore, information dealing with leg dynamic strength characteristics and COD performance at NCAA Division I level is critically needed. The purpose of this study was to address theses areas by analyzing the underlying mechanisms between leg dynamic strength and COD performance in NCAA Division I soccer players.

METHODS: Subjects for this study included 24 collegiate soccer players (male athletes n=12, female athletes n=12) who participated and competed at NCAA Division I level. Data collection was part of East Tennessee State University (ETSU) long-term athletes monitoring program. All participants read and signed informed consent documents that were approved by the ETSU Institutional Review Board.
A pre-planned 5-5 COD test modified from Hori et al. (2008) was used to evaluate athletes' COD performance (Figure 1). Athletes were required to sprint 5 m, perform a 180° turn and sprint back to the starting line. Each athlete had two familiarization trials prior to maximal effort trials, in order to minimize the perceptual and decision making component. A total of 4 trials were recorded (two trials performed cutting with left leg, and two trials with right leg). Two sets of timing gates were used to assess athletes' 3m acceleration time (3mAcc), total time (TT) and partial task time (PT). PT was calculated by subtracting athletes' 3mAcc by their TT.

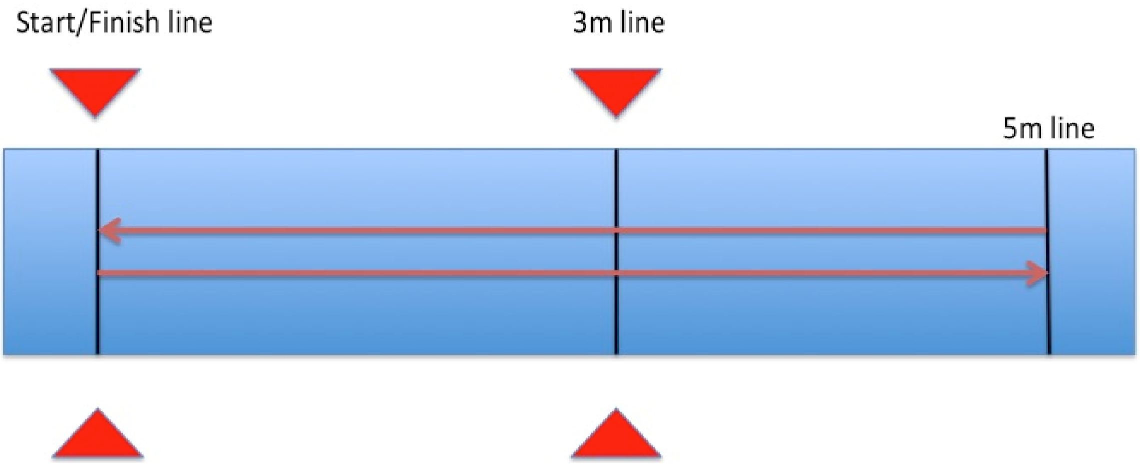

Figure 1: Schematic approach of pre-planned COD test

Countermovement jumps (CMJ) and static jumps (SJ) with loaded (20kg barbell) and unloaded (0kg PVC pipe) conditions were performed on a force plate (Rough Deck HP; Rice Lake, WI), while data was sampled at 1,000 Hz.The vertical jump tests started with the SJ. Athletes stood on a force plate and squatted down to a knee angle at 90° as measured by goniometer. Jumps commands were given after athletes stayed in this bottom position for three seconds. Two trials of each jump (SJ 0kg and SJ 20kg) were completed with 1 minute of rest between each trial. CMJs were tested after approximately 3 min after the SJs to remove any potential neuromuscular fatigue. Athletes performed a CMJ after descending to a self-selected depth. Two trials of two loaded conditions (CMJ 0kg and CMJ 20kg) were also executed with one minute of rest between trials. Eight jumps from SJs and CMJs were measured and variables analyzed from SJs and CMJs included: SJ jump height (SJH, 0kg and 20kg), CMJ jump height (CMJH, 0kg and 20kg), SJ allometric scaled peak power (SJ PPa, 0kg and 20kg) and CMJ allometric scaled peak power (CMJ PPa, 0kg and 20kg). A customized Labview10.0 software program (National Instruments Co., Austin, TX) was utilized to analyze all force-time data. The test-retest reliability of COD and vertical jump tests in this study were calculated using intraclass correlation coefficients (ICC). The relationship of COD test and vertical jumps was assessed using Pearson's zero order product-moment correlations. Prediction of TT was performed via regression analysis (only variables that produced correlation value between -0.71 to -0.81 with TT were analyzed).

RESULTS: All tests from this study are considered reliable, as the test-retest reliability in this study was between 0.87 - 0.97 (COD test ICC: 0.87-0.95, vertical jump tests ICC: 0.93-0.97).

The correlations between COD and vertical jumps variables are shown in Table 1 and Table 2, respectively.

Table 1. Relationship between COD test variables (N=24).

	3mAcc	TT	PT
3mAcc	1	0.71***	0.33
TT	0.71***	1	0.90***
PT	0.33	0.90***	1

*** $P < 0.001$.

Table 1 shows the correlation results between COD test variables. 3mAcc was statistical significant correlated with TT (r =0.71), TT and PT were also strongly and significantly correlated with each other (r =0.90).

Table2. Relationships between vertical jump variables and COD Performance (N=24).

	3mAcc	TT	PT
CMJH 0kg	-0.43*	-0.71***	-0.68***
CMJH 20kg	-0.43*	-0.71***	-0.69***
CMJ PP_a 0kg	-0.36	-0.62**	-0.60**
CMJ PP_a 20kg	-0.33	-0.61**	-0.61**
SJH 0kg	-0.46*	-0.81***	-0.79***
SJH 20kg	-0.41*	-0.71***	-0.70***
SJ PP_a 0kg	-0.37	-0.68***	-0.68***
SJ PP_a 20kg	-0.24	-0.54**	-0.57**

* $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$.

Table 2 shows the correlation results between COD and vertical jump tests variables. All variables except CMJ PPa (0 and 20kg) and SJ PPa (0 and 20kg) were moderate to strongly correlated with each other (r = -0.41 to -0.81).

Stepwise multiple regression analysis shows SJH 0kg accounted for 64% (adjusted R^2 = 0.64, $P < 0.001$) of the variance in COD TT. There was no extreme multicolinearity in the data that ranges from -0.71 to -0.81. SJH 0kg was significant contributor to the description of COD TT.

DISCUSSION: This study examined the relationships between COD performance and leg dynamic strength. The primary findings of this study are a) soccer athletes, who could accelerate faster at first 3m, were more likely to finish the COD test in a shorter time. Sheppard & Young (2006) proposed a theory in terms of three phases movement in a pre-planned COD task, which are: accelerlation (initial movement), deceleration (cutting) and re-accelerlation (turing to new direction). The results from this study not only confirm the theory, but they were also consistent with Jones et al (2009), who found 5m sprint times were significantly related to COD performance (r = -518). b) Vertical jump variables, which represent soccer players' leg dynamic strength, were strongly related to COD performance. Particularly, TT and PT show the strongest correlations (r =0.54 to 0.81), PT also represents athletes' re-acceleration ability. Similar results have also produced in previous study (Castillo-Rodríguez, Fernández-García, Chinchilla-Minguet, & Carnero, 2012). After decelerating, athletes need to overcome their own body weight and inertia, in order to push off and turn to new direction (Spiteri et al., 2013). In vertical jumps, especially static jumps, athletes start their exposiveness movement from a squating position, which may be similar to the transition from deceleration to re-acceleration in a COD test. Unfortunately, the underlying mechanisms are unclear, thus, future research is needed. c) SJH with 0kg can be utilized as a good predictor for soccer athletes' COD performance at NCAA Division I level. Our data are in contrast to those of Barnes et al. (2007) who indicated that CMJH is the best predictor of COD test. It should be noted, the subjects from Barnes et al. (2007) study were females volleyball players ranging from NCAA Division I to Division III levels, and the CMJ is the most commonly used movement in volleyball matches (Ziv & Lidor, 2010). Soccer players are required to perform COD tasks from a variety of positions, including static positions. This movement specificity might explain the difference in predictability for COD performance in different sports, and may also indicate that relationships between dynamic strength and COD performance are related to sport/population tested.

CONCLUSION: This study suggests that vertical jumps with two loading conditions are related to NCAA Division I collegiate soccer players' COD performance. Additionally, COD performance can be estimated by SJH with 0kg. However, questions remain regarding the complex strength characteristics displayed during COD tasks. Throughout a COD test, intensive braking is performed after initial acceleration. Moreover, re-acceleration followed the braking phase may decide the success of overall COD performance. Future investigations are needed to determine if different strength characteristics play special roles during COD tasks.

REFERENCES:

Baker, D. G., & Newton, R. U. (2008). Comparison of lower body strength, power, acceleration, speed, agility, and sprint momentum to describe and compare playing rank among professional rugby league players. *Journal of Strength and Conditioning Research, 22*(1), 153-158.

Barnes, J. L., Schilling, B. K., Falvo, M. J., Weiss, L. W., Creasy, A. K., & Fry, A. C. (2007). Relationship of jumping and agility performance in female volleyball athletes. *Journal of Strength and Conditioning Research, 21*(4).

Castillo-Rodríguez, A., Fernández-García, J., Chinchilla-Minguet, J., & Carnero, E. Á. (2012). Relationship between muscular strength and sprints with changes of direction. *The Journal of Strength & Conditioning Research, 26*(3), 725-732.

Chaouachi, A., Manzi, V., Chaalali, A., Wong del, P., Chamari, K., & Castagna, C. (2012). Determinants analysis of change-of-direction ability in elite soccer players. *Journal of Strength and Conditioning Research, 26*(10), 2667-2676.

Hori, N., Newton, R. U., Andrews, W. A., Kawamori, N., McGuigan, M. R., & Nosaka, K. (2008). Does performanceof hang power clean differentiate performance of jumping, sprinting, and changing of direction? . *Journal of Strength and Conditioning Research, 22*(2), 412-418.

Jones, P., Bampouras, T., & Marrin, K. (2009). An investigation into the physical determinants of change of direction speed. *Journal of Sports Medicine and Physical Fitness, 49*(1), 97-104.

Serpell, B. G., Youg, W. B., & Ford, M. (2011). Are the perceptual and decision-making components of agility trainable?A preliminary investigation. *Journal of Strength and Conditioning Research, 25*(5), 1240-1248.

Sheppard, J. M., & Young, W. B. (2006). Agility literature review: classifications, training and testing. *Journal of Sports Sciences, 24*(9), 919-932.

Spiteri, T., Cochrane, J. L., Hart, N. H., Haff, G. G., & Nimphius, S. (2013). Effect of strength on plant foot kinetics and kinematics during a change of direction task. *European Journal of Sport Science*, 13(6), 646-652

Stolen, T., Chamari, K., Castagna, C., & Wisloff, U. (2005). Physiology of soccer: an update. *Sports Medicine, 35*(6), 501-536.

Vescovi, J. D., & McGuigan, M. R. (2008). Relationships between sprinting, agility, and jump ability in female athletes. *Journal of Sports Sciences, 26*(1), 97-107.

Wisloff, U., Castagna, C., Helgerud, J., Jones, R., & Hoff, J. (2004). Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *British Journal of Sports Medicine,* 38(3), 285-288.

Ziv, G., & Lidor, R. (2010). Vertical jump in female and male volleyball players: a review of observational and experimental studies. *Scandinavian Journal of Medicine and Science in Sports, 20*(4), 556-567.