# ASSOCIATIONS BETWEEN CLINICAL AND PERFORMANCE TESTS IN SOCCER ATHLETES

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This study determined the relationship between selected Functional Movement Screen (FMS™) scores, quadriceps and hamstrings strength, and vertical jump performance to see if there was consistency between clinical and performance testing. Records for twelve NCAA-I female soccer players were selected for this study. The isolated scores from the hurdle step and deep squat portions of the FMS™ test were extracted, left and right peak knee extension and flexion torques from isokinetic tests at 60, 180, and 300 °/s, and vertical jump heights were recorded. Bivariate correlations and a multiple regression analysis were conducted to explore relationships among variables. The FMS™ test was a poor predictor of vertical jump height, but peak extension and flexion torques were related to the vertical jump in a complex relationship.

**KEYWORDS:** countermovement jump, soccer, quadriceps, hamstrings, torque.

**INTRODUCTION:** The vertical jump is a standard performance measurement that is used in multiple sports. The National Football League (NFL) (American football) uses a vertical jump to evaluate players before they are drafted into the NFL (Robbins, 2012). Soccer, baseball, basketball, hockey, softball, and many other sports use the vertical jump as a performance measurement as well. One of the key components making the vertical jump test popular is the association with a high rate of force development (McLellan, Lovell, & Gass, 2011; Peterson, Alvar, & Rhea, 2006).

The FMS™ test is comprised of seven activities that are related to an athlete's mobility, flexibility, and balance. These underlying abilities are necessary for soccer athletes to be successful, which is why the test is often used by coaches or other professionals (Oliveira, Barbieri, & Gonçalves, 2013). While the test is in common use, there are mixed opinions about its validity. Research suggests that the FMS™ test has predictive limitations (Lockie et al., 2015). Parchman & McBride (2011) determined that the FMS™ did not correlate with vertical jump performance. Their variability may be explained by the results of select tests from the FMS™ battery depending on the age of the athlete (Lloyd et al., 2015). More research needs to be conducted to determine if the FMS™ test can be used to predict athletic performance and add useful information to the vertical jump test.

Isokinetic dynamometer testing for torque and power is another performance measurement that is used by coaches and other professionals (Sliwowski, Grygorowicz, Hojszyk, & Jadczak, 2017). Since power and torque are important to a soccer athletes performance, this test is often conducted on the players. Knee extensor muscles at 180°/s on the isokinetic dynamometer have been shown to correlate with vertical jump height, but more research is needed in this area to see if isokinetic testing can be used to verify vertical jump performance (Ostenberg, Roos, Ekdahl, & Roos, 1998).

Clinical and performance tests are crucial to tracking athlete progress as they develop, and also to determine if the strength and conditioning program the athletes undergo are improving their athletic skills. Conducting multiple performance tests helps to verify results, along with providing more insight about the athlete's training progress. The purpose of this study was to determine how FMS™ and isokinetic testing of knee flexion and extension were related to vertical jump performance. A second purpose was to determine if FMS™ and isokinetic testing could add information or demonstrate a consistency with the vertical jump test results. We hypothesized that there would be a positive relationship between all test results and vertical jump height.

**METHODS:** *Participants:* Medical records along with the strength and conditioning records of twelve NCAA-I female soccer players (age range: 18–22 years, height range: 1.55-1.75 m, mass range: 51.25-74.84 kg) were selected for this study. The athletes are evaluated consistently and have familiarity with the performance tests used in this study.

*Protocol and Data Collection:* This study examined data records from testing conducted by sports medicine and strength staff prior to athletes starting an off-season training cycle. This study was approved by the university IRB committee. FMS™ scores were recorded by university staff including the deep squat test and the hurdle step test. For the deep squat test the subject stands with their feet shoulder width apart while holding a pole above their head. The subject is then instructed to perform a squat to the best of their ability going as low as possible. For the hurdle step test the subject stands with their feet together while holding a pole on the back of their shoulders under the subject's neck. The subject steps over a rubber wire that is placed at their tibial tuberosity. For both the deep squat test and the hurdle step test the subject completes three trials, with the best trial being scored (Cook, Burton, Hoogenboom, & Voight, 2014a, 2014b). The athletes were tested on an isokinetic dynamometer at three different speeds of 60°/s, 180°/s, and 300°/s for concentric/concentric knee extension/flexion for both the right and left leg. Knee extension measured quadriceps strength and knee flexion measured hamstrings strength. The athletes warmed up before the testing and had a practice trial. For the vertical jump trial the athletes performed a countermovement jump at maximal effort.

*Instrumentation:* The FMS™ test was scored subjectively according to the test directions. Scores range from 1 to 3 per item, with 3 being the best. Scores from the deep squat test and the hurdle step test items were extracted. Isokinetic testing was completed on a Cybex Humac Norm (Computer Sports Medicine, Inc., Soughton, MA, USA). Vertical jump height was determined using a Just Jump Mat (Power Systems, Knoxville, TN).

*Data Processing:* Variables reduced from the tests were two FMS™ item scores, peak torque of the quadriceps at three speeds, peak torque of the hamstrings at three speeds, and vertical jump height. Peak torque values from the isokinetic testing were normalized by dividing the torque in Nm by the subject's height in meters and weight in Newtons to obtain body weight units (BW) (Jaric, Mirkov, & Markovic, 2005).

*Statistical Analyses:* Bivariate correlations were computed between all FMS™ and torque variables and jump height using SAS (SAS Institute Inc., Cary, NC). A multiple regression analysis was conducted using SAS (SAS Institute Inc., Cary, NC) with vertical jump height as the independent variable and the peak torques as the dependent variables. The stepwise input and removal method was used with $R^2$ as the selection criteria. Statistical significance was set *a priori* as $\alpha = 0.05$ for all tests.

**RESULTS:** A combination of left quad peak torque at 300°/s, left quad peak torque at 180°/s, right hamstring peak torque at 300°/s, and right quad peak torque at 300°/s, accounted for variance in vertical jump height ($F = 10.11$, $p = 0.0049$, adjusted $R^2 = 0.7682$) (Table 1). There were correlations among dependent regression variables (Table 2). The left quad peak torque at 300°/s ($r = 0.667$, $p = 0.0178$) and left quad peak torque at 180°/s ($r = 0.679$, $p = 0.0153$) were correlated with greater vertical jump heights (Figure 1).

**Table 1: Multiple regression coefficients and descriptive statistics**

| | Regression Coefficient | Std. Error | *t* | *p* | Mean ± Std Dev (BW) |
|---|---|---|---|---|---|
| Intercept | 0.345 | 0.048 | 7.13 | <0.01 | |
| LQ300 | 3.626 | 1.122 | 3.22 | 0.015 | 0.615 ± 0.012 |
| LQ180 | 2.288 | 0.712 | 3.21 | 0.015 | 0.087 ± 0.012 |
| RH300 | -0.645 | 0.585 | -1.10 | 0.307 | 0.047 ± 0.013 |
| RQ300 | -3.894 | 1.655 | -2.35 | 0.051 | 0.060 ± 0.009 |

**Table 2: Bivariate correlations among independent and dependent regression variables**

| | VJ | LQ300 | LQ180 | RH300 | RQ300 |
|---|---|---|---|---|---|
| VJ | 1.000 | | | | |
| LQ300 | 0.667 (0.018) | 1.000 | | | |
| LQ180 | 0.679 (0.015) | 0.629 (0.028) | 1.000 | | |
| RH300 | -0.319 (0.313 | 0.114 (0.724) | 0.131 (0.684) | 1.000 | |
| RQ300 | 0.386 (0.216) | 0.860 (<0.01) | 0.683 (0.014) | 0.377 (0.227) | 1.000 |

Notes: N= 12; VJ = vertical jump height; LQ300 = left quadriceps peak torque at 300°/s; LQ180 = left quadriceps peak torque at 180°/s; RH300 = right hamstring peak torque at 300°/s; RQ300 = right quadriceps peak torque at 300°/s.

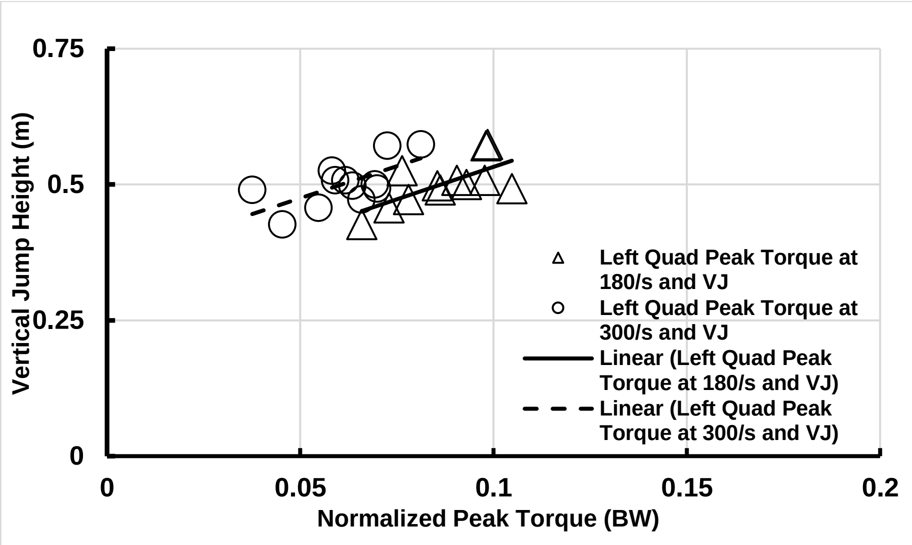


**Figure 1: Associations among left quad peak torques and vertical jump height.**

**DISCUSSION:** The purpose of this study was to determine how selected FMS™ scores and isokinetic knee flexion/extension peak torques were related to vertical jump performance to verify the vertical jump results and provide insight about the athlete. The results from the statistical analysis indicate that there was no relationship between the two FMS™ test items selected and vertical jump height. This does not support our hypothesis, but agrees with previous research that states there are limitations to the FMS™ testing (*Lloyd et al.*, 2015; Lockie *et al.*, 2015). An issue with the FMS™ test is the qualitative scoring scale that ranges from 1 to 3. This can lead to a lack of variability with similar scores between subjects making it hard to differentiate what the scores actually mean. The test is subjective. Multiple raters may give differing scores for the same subject. FMS™ may have a place in functional testing, but it has limitations that make it a poor predictor for vertical jump height and it does not provide additional information about the athlete.

The isokinetic dynamometer results demonstrated significant relationships to vertical jump performance, which supports our hypothesis. The left quad peak torque at 300°/s and left quad peak torque at 180°/s were positively correlated with greater vertical jump heights (Figure 1). This relationship indicates that the speeds of 300°/s and 180°/s are better at predicting vertical jump height then a speed of 60°/s, which agrees with previous literature (Ostenberg et al., 1998). A higher peak torque value from the isokinetic testing can help to predict a higher vertical jump height. Only the left leg was significant, but this could be due to a limitation in the study of a small sample size and having more left leg dominant than right leg dominant athletes. Future studies should include a larger sample size, both genders, and an even amount of left/right dominant athletes.

A combination of left quad peak torque at 300°/s, left quad peak torque at 180°/s, right hamstring peak torque at 300°/s, and right quad peak torque at 300°/s, accounted for variance in vertical jump height (Table 1). The positive weights for left quad peak torque at 300°/s and left quad peak torque at 180°/s were the same as for the simple correlations. The negative weights for right hamstring peak torque at 300°/s and right quad peak torque at 300°/s suggested that the right leg was also a predictor of jump height, but with a complex relationship. The relationship effect of the right leg hamstring and quadriceps peak torque suggested a common cause between right and left sides, which is likely leg dominance. These significant torques were also at the higher speeds, suggesting the speeds of the dynamometer closest to the speeds of the jump are the best predictors, which makes sense for test specificity. Knee strength in elite soccer changed significantly at higher isokinetic velocities when compared to lower velocities over the course of a season (Eniseler, Şahan, Vurgun, & Mavi, 2012).

**CONCLUSION:** The data from this study suggests that the FMS™ test is not consistent with vertical jump performance and it does not add any additional information about the athlete. The isokinetic dynamometer, on the other hand, is related to vertical jump height and may be used injunction with the vertical jump to provide more insight about the athlete, especially at the 300°/s and 180°/s speeds. The use of an isokinetic dynamometer along with the vertical jump test results will allow staff to gain the most information about the athlete. This information provides coaches, sports medicine staff, and strength/conditioning staff with an additional choice for measuring athletic attributes.

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