IJAHSP
The Internet Journal of Allied Health Sciences and Practice
http://ijahsp.nova.edu

A Peer Reviewed Publication of the College of Allied Health & Nursing at Nova Southeastern University
Dedicated to allied health professional practice and education
http://ijahsp.nova.edu Vol. 8 No. 2 ISSN 1540-580X

The Effect of Quality of Movement on the Single Hop Test in Soccer Players Aged 15-16 Years

James R. Roush, PhD, PT, ATC[1]
Katherine DoVico, PT, DPT[1]
Sheryl Fairchild, PT, DPT, ATC[1]
Kimberly McGriff, PT, DPT, ATC[1]
R. Curtis Bay, PhD[2]

1. Department of Physical Therapy, AT Still University, Arizona
2. Department of Interdisciplinary Studies, AT Still University, Arizona

United States

CITATION. Roush, JR., DoVico, K., Fairchild, S., McGriff, K., Bay, RC. The Effect of Quality of Movement on the Single Hop Test in Soccer Players Aged 15-16 Years. *The Internet Journal of Allied Health Sciences and Practice*. April 2010. Volume 8 Number 2.

ABSTRACT

Sports injuries are one of the most common injuries in modern society. The anterior cruciate ligament (ACL) is commonly injured in sports. Soccer is one of many sports where an ACL injury is likely to occur, due to inherent jumping and pivoting during participation. Abnormal movement patterns have been suggested as a risk factor for knee injuries, which lead to the development of the step-down test. The Single Leg Hop for Distance test is used to assess functional performance in individuals with an ACL injury or reconstruction. The purpose of the current study was to determine if there are differences in hop test distances according to scores on the step-down test. A second purpose is to determine the relationship between hop test distances and height. Sixty-one males and sixty-one females between 15 and 16 years who participated in a club soccer program participated in the study. The Hop test and the step-down test were administered to the subjects. Mean hop distance for males was 172.89 cm (SD = 18.27) and the mean hop distance for females was 146.88 cm (SD = 14.63). For both males and females, there were no differences in hop distances between the left and right lower extremity (LE). There were no differences in hop distances according to classification of the step-down test for males. Females classified as good by the step-down test hopped farther than females classified as poor. There were no relationships between distances in the hop test and height in females (r = .23 for the left LE; .21 for the right LE). There was a low relationship between distances in the hop test and height in males (r = .46 for the left LE; .39 for the right LE). Clinicians may utilize this information for goal setting and objective testing during rehabilitation.

INTRODUCTION

Sports injuries are one of the most common injuries seen in modern society.[1] Between 10% and 25% of the individuals who are injured while competing in sports are between the ages of 13 and 19 years.[2] Complete knee injuries from soccer account for 74.2% of all necessary surgical interventions for girls.[3] Boys sustain 1.98 knee injuries requiring surgical intervention per 100,000 athlete encounters; whereas, girls sustain 26.4 knee injuries requiring surgical intervention per 100,000 athlete encounters. [3]

It has been noted that the anterior cruciate ligament (ACL) is commonly injured in sports, resulting in pervasive knee dysfunction.[4,5] This injury is frequently observed in males and females between 14 and 20 years.[5] Soccer is one of many sports where an ACL injury is likely to occur, probably because this sport inherently involves jumping and pivoting.[3,5,6] In boy's soccer,

injuries that require surgical interventions are complete knee ligament rupture, incomplete knee ligament sprain, menisci damage, and upper leg or thigh fracture, which accords for 36.1% of all necessary surgical interventions for this sport.[7] The monetary cost of anterior cruciate reconstruction without the initial evaluation and without rehabilitation has been estimated at approximately $1 billion per year in the United States.[8]

Abnormal movement patterns have been suggested as a risk factor for a predisposition for knee pain and knee injuries.[9] This premise lead to the development of the step-down test. It is believed that by screening for abnormal movement patterns, at-risk individuals can be identified and referred to prevention programs that teach individuals proper mechanics for activities that require deceleration, changing direction, and landing from a jump.[9]

Rehabilitation for returning to sport participation is essential in decreasing the potentially deleterious effects of an ACL injury. The Single Leg Hop for Distance test (hop test) has been commonly used to assess functional performance in individuals with an ACL injury or reconstruction.[10-20] De Carlo and Sell published normative data for the hop test with high school athletes and reported mean values for males (154 cm on the right lower extremity and 155 cm on the left lower extremity) and females (122 cm on the right lower extremity and 120 cm on the left lower extremity) for 14-year-old participants in a variety of high school sports.[17] However, the data provided by De Carlo and Sell were not specific to any one sport.

The step-down test is a commonly used, reliable, functional test for patients with anterior knee pain and a screening tool for assessing quality of movement of the lower extremity and knee dysfunction.[2,9] To evaluate the quality of movement when performing a step-down test, the patient is subjectively graded as “good,” “medium,” or “poor” by the clinician on how well he/she descends from a 20 cm step. Since the hop test is used as a functional assessment for return to sport for individuals with ACL injury or reconstruction, the question to be addressed is whether quality of movement as determined by the step-down test influences the ability to perform the hop test. As the hop test has been cited on numerous occasions as functional test, another purpose is to determine the relationship between height and hop distance.

METHODS

Subjects

This study was approved as safe for human subjects by the Institutional Review Board (IRB) of A.T. Still University - Mesa. All subjects participating in this study were required to read and sign an informed consent prior to participation. Only subjects 15 and 16 years old were allowed to participate, as they were part of one youth soccer league. Only healthy subjects participated in the study. Subjects were not excluded if they were also participating in a high school soccer program. Subjects were excluded if they reported any recent histories of anterior cruciate ligament injuries, tibial or fibular collateral ligament injuries, menisci injuries, or back pain. Subjects were also excluded if they reported an ankle sprain within the past 3 months.

Data Collection Procedures

Height for each subject was measured and recorded with a standard tape measure as the subject stood against a wall. Weight for each subject was measured and recorded with a standard bathroom scale. Dominant leg, as determined by which leg the subject preferred to kick a ball, was recorded.

The Step-down Test

The subjects were asked to perform a step-down test as described by Piva et al.[9] The procedure for administering the step-down test can be found in Table 1. Each lower extremity was assessed. Two investigators were trained by the primary investigator and evaluated for their reliability in conducting the test against a clinician with over 25 years of clinical experience working in a sports environment. A Kappa coefficient of greater than .80 was calculated for each investigator.

TABLE 1. Procedure for Conducting the Step-Down Test

1.	The subject is asked to stand in single limb support with the hands on the waist, the knee straight and the foot positioned close to the edge of a 20-cm high step.
2.	The contralateral leg is positioned over the floor adjacent to the step and is maintained with the knee in extension.
3.	The subject then bends the tested knee until the contralateral leg gently contacts the floor and then re-extends the knee to the start position.
4.	This maneuver is repeated five times.

Assessment of the performance of subjects on the step-down test can be found in Table 2.

TABLE 2. Assessing the Step-Down Test

1. Arm strategy	• If subject used an arm strategy in an attempt to recover balance, one point is added.
2. Trunk movement	• If the trunk leaned to any side, one point is added.
3. Pelvis plane	• If pelvis is rotated or elevated on one side compared with the other, one point is added.
4. Knee position	• If the knee deviated medially and the tibial tuberosity crossed an imaginary vertical line over the second toe, add one point; or if the knee deviated medially and the tibial tuberosity crossed an imaginary vertical line over the medial border of the foot, add two points.
5. Maintain steady unilateral stance	• If the subject stepped down on the non-tested side, or if the subject's tested limb became unsteady (i.e. wavered from side to side on the tested side), one point is added.

Total score of 0 or 1 was classified as good quality of movement; total score of 2 or 3 was classified as medium quality, and total score of 4 or above was classified as poor quality of movement.

The Hop Test

The subjects were instructed to perform the hop test as described by Kramer et al.[19] The procedure for the hop test can be found in Table 3. The subject was instructed to jump off one leg and to land on the same leg, without losing balance or stepping onto the opposite leg. If the subject lost their balance, he/she was required to complete that hop again. The test was completed with the arms free; that is, the subject's arms could be used to assist with balance and to generate momentum during the jump. Three hops were then completed using alternate legs. By a flip of a coin, the non-dominant leg was measured first for all subjects. Approximately 30 seconds elapsed between hops. The subject was not informed of his/her score for each jump and was asked simply to jump as far as possible without falling over or putting the non-hop leg down to restore balance. The average of the three trials was used for data analysis.

TABLE 3. Procedure for Single Leg Hop for Distance Test

1.	Subject is instructed to jump as far as possible off one leg and land on that same leg without losing balance.
2.	Subjects will repeat this test three times on each leg, alternating sides.
3.	If balance is lost, subject will be asked to repeat the jump.
4.	The subject's toes must stay behind the start line for the start of each jump.
5.	The heel of the hop leg will be used to determine the length (in centimeters) of the jump.
6.	Subject will not be informed of their score for each jump and will be allowed approximately 30 s of rest between each hop.
7.	The average of all three hops will be taken for each leg.

Data Analysis Procedures

Descriptive statistics were used to characterize height, weight, and leg dominance for the subjects in the sample. A quasi-experimental design and a correlational design were utilized in the development of the study. A dependent t test was performed to determine if there was differences in hop distances according to left or right lower extremity. Pearson product-moment correlation coefficients, 95% confidence intervals, and coefficients of determination were calculated to determine relationships and shared variability between height and scores according to sex and side. A two-way analysis of variance was calculated with the main effects of sex and quality of movement to identify significant differences in distances when performing the hop test. An alpha level of .05 was adopted for significance. The data were analyzed using the SPSS (15.0) statistical software package (SPSS, Inc, Chicago, Illinois).

RESULTS

Sixty-one males and sixty-one females who were participating in a competitive, youth soccer club participated in the study. Although participation was voluntary, all members of the soccer club for both sexes participated in the study. The descriptive statistics for the sample can be found in Table 4. Using the simple test of which leg the subject preferred to kick a ball, 54 of the 61 males and 58 of the 61 females demonstrated right-leg dominance.

TABLE 4. Descriptive Statistics of the Sample

	Male (N= 61)		Female (N = 61)	
	Mean	SD	Mean	SD
Height (cm)	174.22	7.38	165.06	5.84
Weight (kg)	64.29	7.65	56.87	5.59
Hop Distance (cm)				
Average of Right and Left Lower Extremities	172.89	18.27	146.88	14.63

Descriptive statistics for the Hop test according to sex and step-down test are provided in Table 5. Hop distances between the right lower extremity and left lower extremity were not different in males (mean difference = 2.13 cm; t = 1.57; df = 60; p = .12) or in females (mean difference = 0.36 cm; t = 0.35; df = 60; p = .73). For females, there were no significant differences in hop distances according to classification by the step-down test for the right lower extremity (Figure 1); while for the left lower extremity, those with a good step-down test performed longer hop distances than subjects with a poor step-down test (F = 3.13; df = 2,116; p= .048). For males, there were no significant differences in hop distances according to step-down scores for either lower extremity (F = 1.372; df = 5,115; p= .24).

Figure 1. Means and 95% Confidence Intervals of Hop Test Distance by Step-Down Test

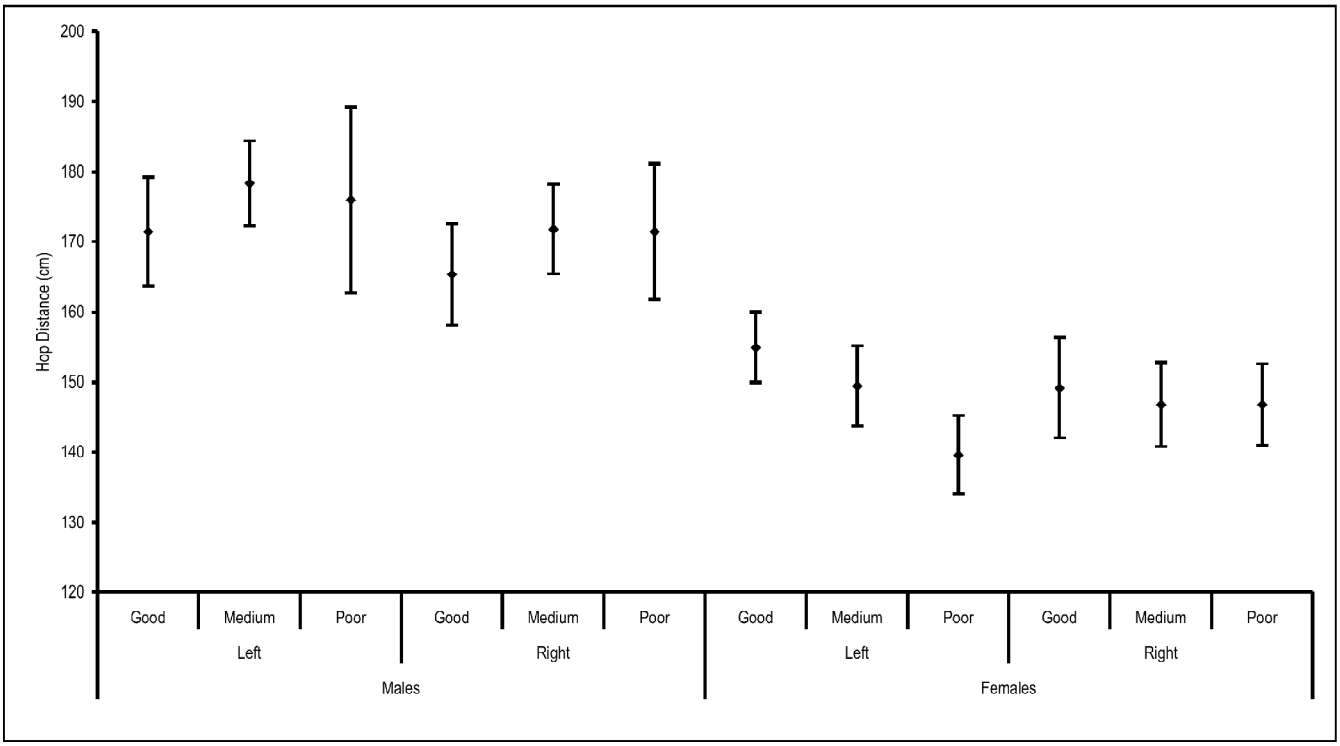

TABLE 5. Means and Standard Deviations of Hop Test Distance (cm) according to Sex and Classification by Step-Test Score

		Step Test	Mean	SD	N
Males	Left Lower Extremity	Poor	175.98	24.14	13
		Medium	178.38	16.75	29
		Good	171.48	17.44	19
		Overall Average	175.72	18.72	61
	Right Lower Extremity	Poor	171.46	16.35	11
		Medium	171.82	19.04	34
		Good	165.38	14.82	16
		Overall Average	170.07	17.52	61
Females	Left Lower Extremity	Poor	139.59	14.16	25
		Medium	149.50	16.45	22
		Good	155.00	9.64	14
		Overall Average	146.70	14.35	61
	Right Lower Extremity	Poor	146.79	14.80	25
		Medium	146.77	16.56	29
		Good	146.19	9.56	7
		Overall Average	147.05	15.01	61

Correlations between height and scores on the hop test can be found in Table 6. The coefficients for the females were not significant as determined with the 95% confidence intervals. The shared variability between height and hop distance were very close to zero. Although the coefficients for the males were significant, they were considered low. The shared variability between height and hop distance was also considered low.

TABLE 6. Correlations with 95% confidence intervals (CI) and coefficients of determination between height and hop distance according to sex.

		r	95% CI	r^2
Females	Left	.23	-.03 to .46	.05
	Right	.21	-.04 - .45	.05
Males	Left	.46 *	.23 - .64	.21
	Right	.39 *	.15 - .59	.16

* signficant at alpha level of .05.

DISCUSSION

It was hypothesized that there are differences in hop distances according to step-down classification, as individuals who are classified as medium or poor on the step-down test may not hop as far as individuals who are classified as good. In this study, there were no differences in male hop distances according to step-down classification. Females classified as good by the step-down test hopped farther than females classified as poor; however, there were no differences in hop distances between those subjects classified as good or medium, and in hop distances between those subjects classified as poor or medium. Therefore, the classification system within the step-down test may not correspond to an individual's performance in the hop test; and by extension, the test may not correspond to an individual's progression in a rehabilitation program and ultimate return to activity.

For both males and females, distances hopped were not significant between lower extremities. Therefore leg dominance should

not be a factor in the performance of the test. For females, there was no correlation between classification by step-down test and hop distance for the right leg, but there was for the left lower extremity. Only 3 of the 61 female subjects were left-leg dominant. Perhaps a lack of coordination or decreased motor control could contribute to this finding, which is deserving of further study.

For females, height was not significantly related to distance hopped. However, for males, height was significantly related to distance hopped. Therefore, males may be developing more power at this age. Power can be defined as the ability to exert muscular strength quickly. [21] This result warrants further investigation as it would be interesting to determine if the hop test is an appropriate indicator of power for this age group.

Criteria are needed to progress individuals through the rehabilitation process and return-to-sport following injury. Functional testing is necessary to evaluate the progress of an individual who is progressing in the rehabilitation process following a knee injury.[22] For the knee these tests may include running, hopping, and cutting. [22] The hop test has been cited extensively as a functional test for assessing the rehabilitation process for individuals who have had an anterior cruciate injury since its introduction in the early 1980's by Noyes et al.[23] The test is usually used as part of a battery of assessments for detecting knee dysfunction. The battery may include skills such as figure-8 running for time, running up and down a spiral staircase, running up and down a slope, isokinetic/isometric testing, one-legged vertical jump, one-legged hop for time, shuttle run with and without a pivot, cross-over trip hop, and stabiometry.[13,24-,28] The test has been used in longitudinal studies to track patients for as long as 15 years.[27] Furthermore, the test has been generally accepted in terms of its ability to predict general knee stability and as part of general guidelines for the rehabilitation of patients with anterior cruciate deficiency.[11,29] Overall, the hop test was developed as a functional tool for assessing progress in a rehabilitation program and return-to-sport for the lower extremity.[10-20]

However, by standards used to evaluate functional testing at this time, the hop test requires further statistical evaluation to determine its validity. The sensitively of the hop test was calculated at a modest .52 with a specificity of .97.[30] Therefore, the test is very good at ruling out knee dysfunction, but not very good at ruling in knee dysfunction. Furthermore, the cutoff point for the hop test was not determined by a receiver operator characteristic curve, but rather using the recommendations from Barber et al., who determined the cutoff point from a small and extremely diverse sample.[25]

Subject's perception on their progress in the rehabilitation process using the hop test has also been investigated. Wilk et al. reported the relationship between the hop distance and a subject's perception on their progress in the rehabilitation process was a low but significant .31. The coefficient of determination for this relationship is .10, which means that only 10% of the variability in the hop test can be explained in the subject's perception of their progress.[13] While the hop test may be used by many clinicians as a functional test for progression in rehabilitation or return to sport, the subject may not perceive its importance.

The work for using the hop test as a functional test is incomplete. Until these issues can be addressed, the test should not be use solely as a basis for progression in the rehabilitation process. If a battery of tests is used for progression and return to sport for subjects with knee pain, each of the items in the battery would also need to be evaluated for its validity.

There were several limitations of the study. A sample of healthy, 15 to 16 year-old, youth soccer club players who participated in the Phoenix, Arizona metropolitan area was used in the study, and our results may not be generalized beyond this age group or sport. Although the entire population of eligible subjects who participated in the soccer club participated in the study, the sample size was limited to 61 females and 61 males. The age of the subjects in our study ranged between 15 and 16 years, which corresponds with the competition level of U15 and U17 according to the United States Soccer Federation.[31]

CONCLUSION

There were no differences in hop distances according to classification of the step-down test for males. Females classified as good by the step-down test hopped farther than females classified as poor; however, there were no differences in hop distances between those subjects classified as good or medium, and in hop distances between those subjects classified as poor or medium. There were no relationships between distances in the hop test and height in females, and low relationship between distances in the hop test and height in males. Clinicians may be able to utilize this information for goal setting as well as objective testing measures for progressing in the rehabilitation process for any individual with an injury to the lower extremity.

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