THE RELIABILITY OF TWO DIMENSIONAL KINEMATIC ASSESSMENT OF A 45-DEGREE SIDE STEP CUT.

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**Background:** Up to 70% of all anterior cruciate ligament (ACL) injuries occur via a non-contact mechanism involving deceleration and direction change on a planted foot. Clinical screening tools analyzing movement patterns during a cutting task are reliable and valid. The Expanded Cutting Alignment Scoring Tool (E-CAST) is a reliable tool to qualitatively assess trunk and lower extremity (LE) alignment during a 45-degree side step cut (SSC). Previous works found two-dimensional (2D) kinematic analysis more reliable than qualitative assessments when evaluating jumping and squatting movements. However, there is limited evidence on the reliability of 2D assessments to evaluate SSC tasks.

**Hypothesis/Purpose:** To determine if using 2D kinematic analysis with the E-CAST improves the tool’s reliability for evaluating trunk and LE alignment during a 45-degree SSC.

**Methods:** 25 healthy females (age 13.8 ± 1.4 years, mass 52.4 ± 9.3 kg, height 161.7 ± 6.0 cm) who regularly participated in cutting or pivoting sports were included. A repeated measures study design was used. Each subject performed three SSC trials with one trial randomly selected for analysis. Trials were recorded in the frontal and sagittal planes. Two physical therapist raters independently viewed and scored each video on two separate occasions. Videos orders were randomized and a two-week wash out period occurred between rounds. The E-CAST evaluates six movement variables (Figure 1). The assessment criteria for each variable was adapted to utilize the Dartfish motion analysis application on a smart phone (Figure 2). If a movement variable falls outside of the motion analysis definition, the subject scores a point, therefore a higher score represents poorer technique. Intraclass correlation coefficients (ICC) and 95% confident intervals (95% CI) were calculated for the E-CAST total score, and a kappa coefficient was calculated for each variable. Correlations were converted to z scores and compared for significance.
Results: The cumulative intra-rater reliability was good (ICC = 0.821, 95% CI 0.687 – 0.898) and the cumulative inter-rater reliability was moderate (ICC = 0.752, 95% CI 0.565-0.859). Intra-rater kappa coefficients ranged from moderate to almost perfect for all variables (k= 0.505-0.875) and inter-rater kappa coefficients ranged from slight to good for all variables (k=0.336-0.733).

Conclusion: The use of 2D kinematic analysis resulted in higher intra-and inter-rater reliability compared to the traditional qualitative E-CAST (ICC: 0.77, 95% CI 0.59-0.96 and ICC: 0.71, 95% CI 0.50-0.91), however, the difference was not significant (Z_{obs} = -0.46 and Z_{obs} = -0.30).

References:
1. Butler LS, Milian EK, DeVerna A, et al. Reliability of the Cutting Alignment Scoring Tool (CAST) to Assess Trunk and Limb Alignment During a 45-Degree Side-Step Cut. Int J Sports Phys Ther. 2021;16(2):312-321. Published 2021 Apr 1. doi:10.26603/001c.21419
2. Dempsey AR, Lloyd DG, Elliott BC, Steele JR, Munro BJ, Russo KA. The effect of technique change on knee loads during sidestep cutting. Med Sci Sports Exerc. 2007;39(10):1765-1773. doi:10.1249/mss.0b013e31812f56d1
3. Donelon TA, Dos'Santos T, Pitchers G, Brown M, Jones PA. Biomechanical Determinants of Knee Joint Loads Associated with Increased Anterior Cruciate Ligament Loading During Cutting: A Systematic Review and Technical Framework. Sports Med Open. 2020;6(1):53. Published 2020 Nov 2. doi:10.1186/s40798-020-00276-5
4. Dos'Santos T, McBurnie A, Donelon T, Thomas C, Comfort P, Jones PA. A qualitative screening tool to identify athletes with 'high-risk' movement mechanics during cutting: The cutting movement assessment score (CMAS). Phys Ther Sport. 2019;38:152-161. doi:10.1016/j.jpts.2019.05.004
5. Sutton KM, Bullock JM. Anterior cruciate ligament rupture: differences between males and females. J Am Acad Orthop Surg. 2013;21(1):41-50. doi:10.5435/JAAOS-21-01-41
6. Weir G, Alderson J, Smailes N, Elliott B, Donnelly C. A Reliable Video-based ACL Injury Screening Tool for Female Team Sport Athletes. Int J Sports Med. 2019;40(3):191-199. doi:10.1055/a-0756-9659
**Figure 1. Expanded Cutting Alignment Scoring Tool (E-CAST)**

| Item                                                                 | View     | Operational Definition                                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------------------------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trunk lean to opposite direction of cut                              | Frontal  | At the time point of initial load acceptance, if the whole trunk segment appears to be deviated greater than 10 degrees from a horizontal line through the hips (ASIS* to ASIS*) score 1 (YES). If not, score 0 (NO).                                                                                                          |
| Increased cut width                                                  | Frontal  | At the time point of initial load acceptance, draw a line down from the lateral most aspect of the athlete’s stance leg hip, if the line appears to fall more than one shoe width medial to the foot score 1 (YES). If not, score 0 (NO).                               |
| Knee valgus at initial load acceptance (static evaluation)          | Frontal  | At the time point of initial load acceptance, if the weight bearing limb demonstrates valgus (thigh adduction, genu valgum, or knee abduction) score 1 (YES). If the weight bearing limb is in neutral alignment score 0 (NO).                                            |
| Knee valgus throughout the cutting task (dynamic evaluation)        | Frontal  | During the cutting task if the weight bearing limb demonstrates valgus (thigh adduction, genu valgum or knee abduction) score 1 (YES). If the weight bearing limb is in neutral alignment, score 0 (NO).                                                                 |
| Decreased knee flexion angle                                         | Sagittal | At the time point of initial contact, if the athlete demonstrates a stiff or extended knee position score 1 (YES). If the athlete demonstrates a flexed knee position (approximately > 30°), score 0 (NO).                                                                                                   |
| Decreased plantar flexion angle                                     | Sagittal | At the time point of initial contact, if the stance foot lands heel to toe score 1 (YES). If the stands foot lands toe to heel score 0 (NO).                                                                                                                                                     |

*ASIS= Anterior Superior Iliac Spine
Figure 2. E-CAST with 2-D Kinematic Measurement Definitions

| Item                                | View      | 2-D Kinematic Measurement Definitions                                                                                                                                                                                                 |
|-------------------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trunk lean to opposite direction of cut | Frontal   | At the time point of initial load acceptance, draw a line connecting the athlete’s right and left ASIS (hip line). Next, draw a line from the center of the head to the midpoint of the hip line (trunk line). Measure the angle formed between the trunk line and vertical. If the trunk line is deviated greater than 10° score 1 (YES). If the trunk line is deviated less than or equal to 10° score 0 (NO). |
| Increased cut width                 | Frontal   | At the time point of initial load acceptance, draw a line down from the lateral most aspect of the athlete’s stance leg hip, if the line appears to fall more than one shoe width medial to the foot score 1 (YES). If not, score 0 (NO).            |
| Static valgus                       | Frontal   | At the time point of initial load acceptance measure the angle formed between the stance limb hip, knee and ankle joint centers. If the angle formed is greater than 8° score 1 (YES). If the angle formed is less than or equal to 8° score 0 (NO). |
| Dynamic valgus                      | Frontal   | Measure the angle formed between the stance limb hip, knee and ankle joint centers at the maximum point of knee valgus during the cut. If the angle formed is greater than 8° score 1 (YES). If the angle formed is less than or equal to 8° score 0 (NO). |
| Decreased knee flexion angle        | Sagittal  | At the time point of initial contact, measure the angle formed between the lateral hip, lateral knee and lateral malleolus. If the angle formed is less than 30° score 1 (YES). If angle formed is greater than or equal to 30° score 0 (NO). |
| Decreased plantar flexion angle     | Sagittal  | At the time point of initial contact, measure the angle formed between the lower leg and the bottom sole of the shoe. If the angle formed is less than 90° score 1 (YES). If the angle formed is greater than or equal to 90° score 0 (NO). |

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