

Visual Video Analysis Scoring Versus Automated Two-Dimensional Movement Analysis Scoring of the Double-Leg Squat and Single-Leg Squat: A Reliability Study

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BACKGROUND

Biomechanical assessments of multi-joint movements, such as squatting, are commonly performed by sports medicine professionals to identify deficits in mobility and neuromuscular control.¹⁻² There are many movement analysis methods, including visual observation, two-dimensional (2D) analysis, and three-dimensional (3D) motion capture. With a demand for efficiency in athlete screening, user-friendly movement analysis systems aided by artificial intelligence are increasing in popularity.³

OBJECTIVES

The purposes of this study were:

- To establish the interrater reliability of double-leg squat (DLS) and single-leg squat (SLS) scoring between trained physical therapists.
- To assess interrater reliability of DLS and SLS scoring between an automated 2D motion analysis system (Fusionetics™) and the majority score of the raters.

METHODS

- Following a five-minute warm-up on a stationary bicycle, 12 collegiate soccer players (mean age 19.2 years; seven females) were videotaped performing five repetitions of the DLS with arms overhead (front and side views) and the SLS with hands on hips (front view only) using a tablet device (Figures A-D; Table 1).
- The Fusionetics™ system automatically scored the movements based on binary kinematic criteria (Table 2).
- Five licensed physical therapists were trained in the scoring system. They watched the recorded squatting videos a maximum of four times at normal play-back speed and scored each participant's performance of the DLS and SLS.
- Interrater reliability was calculated with the Fleiss Kappa statistic (Table 3).

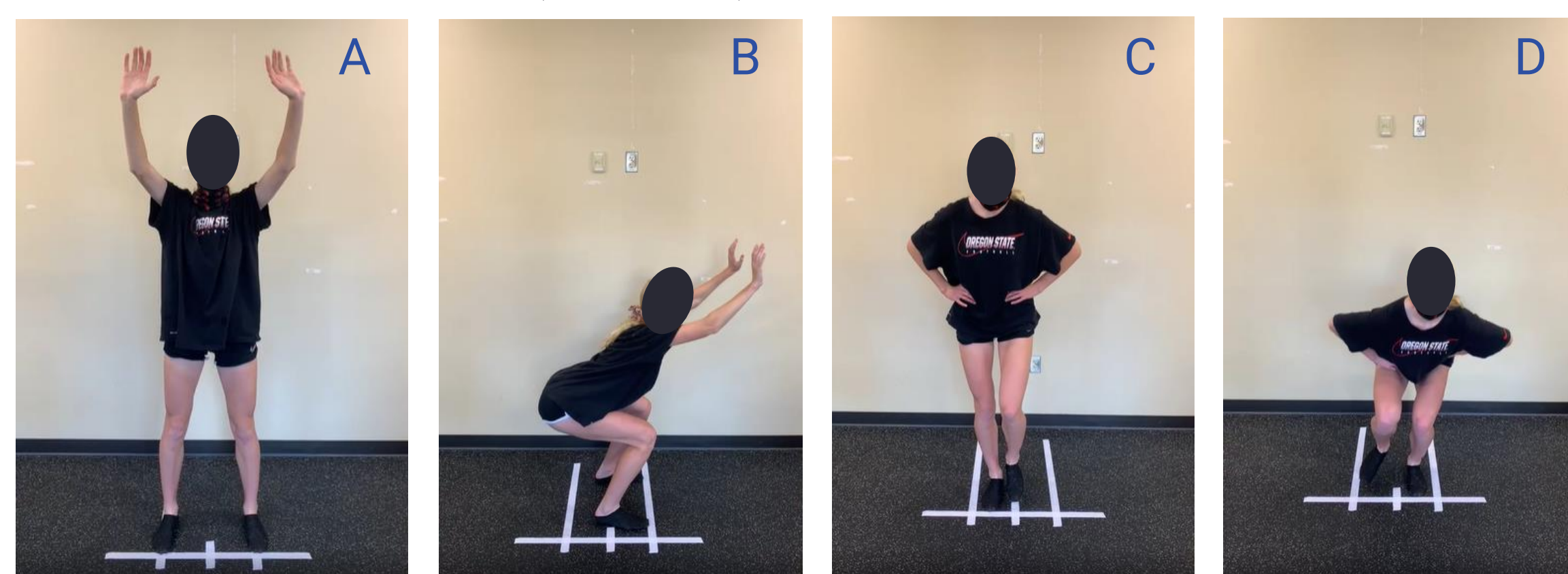
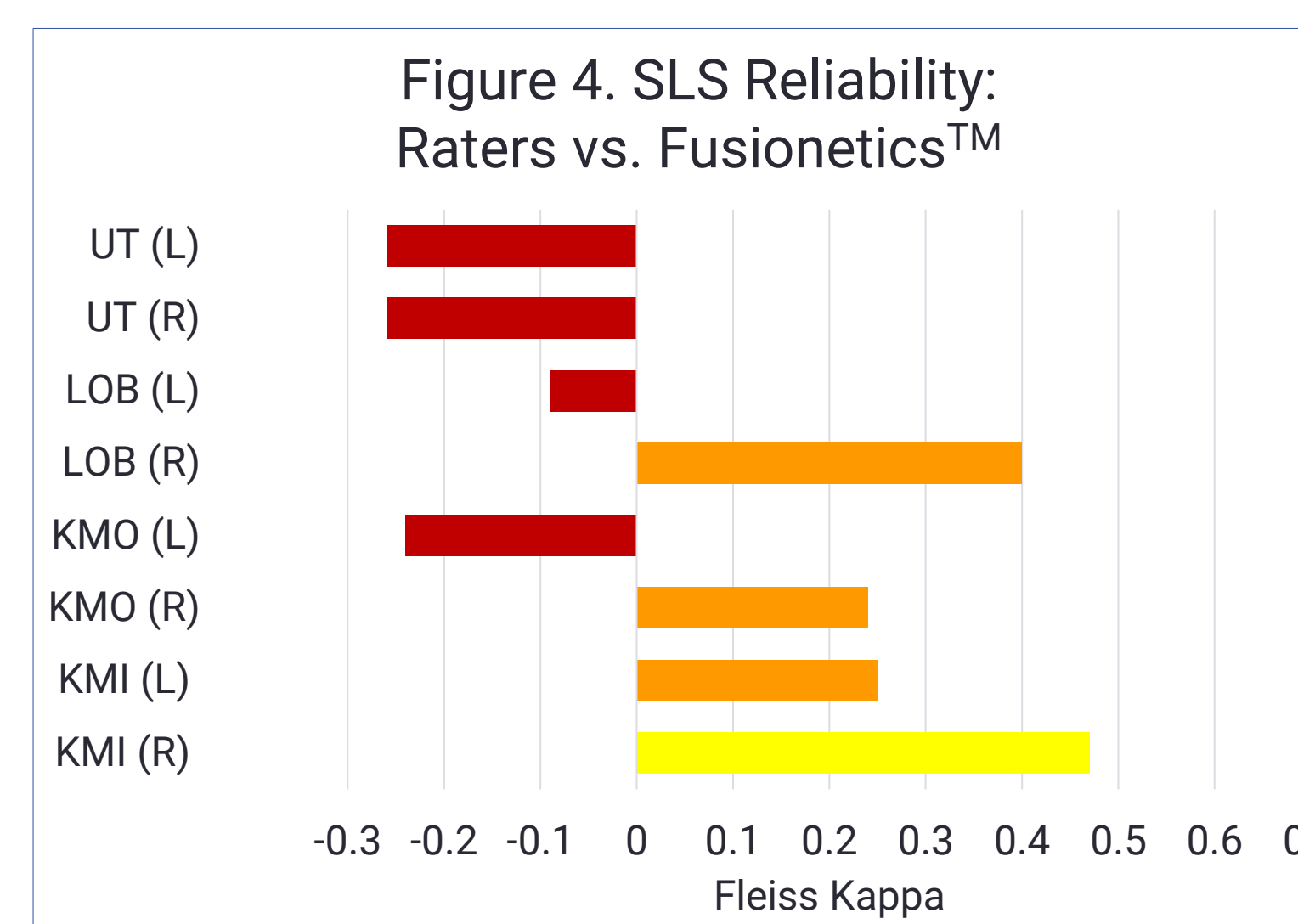
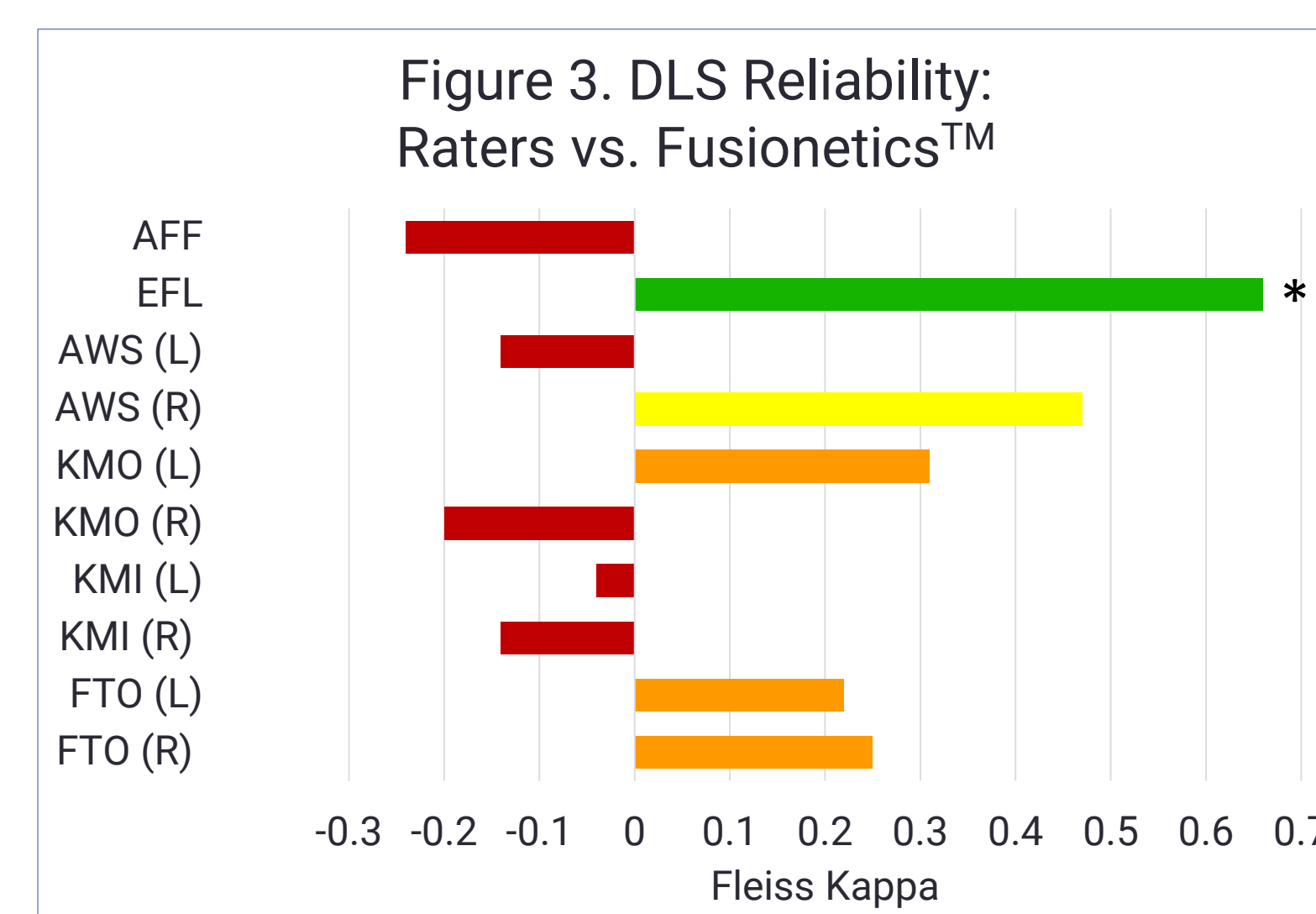
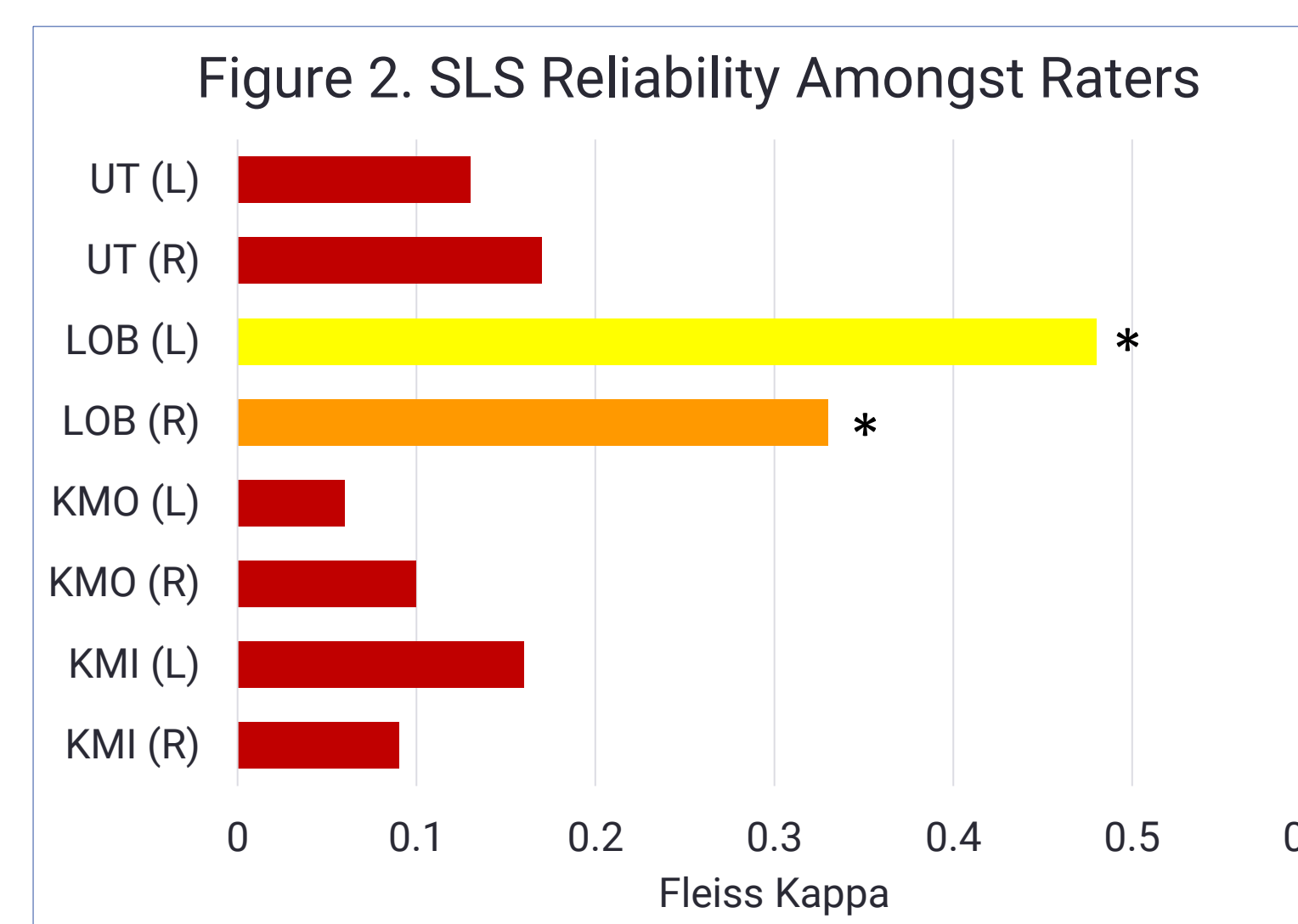
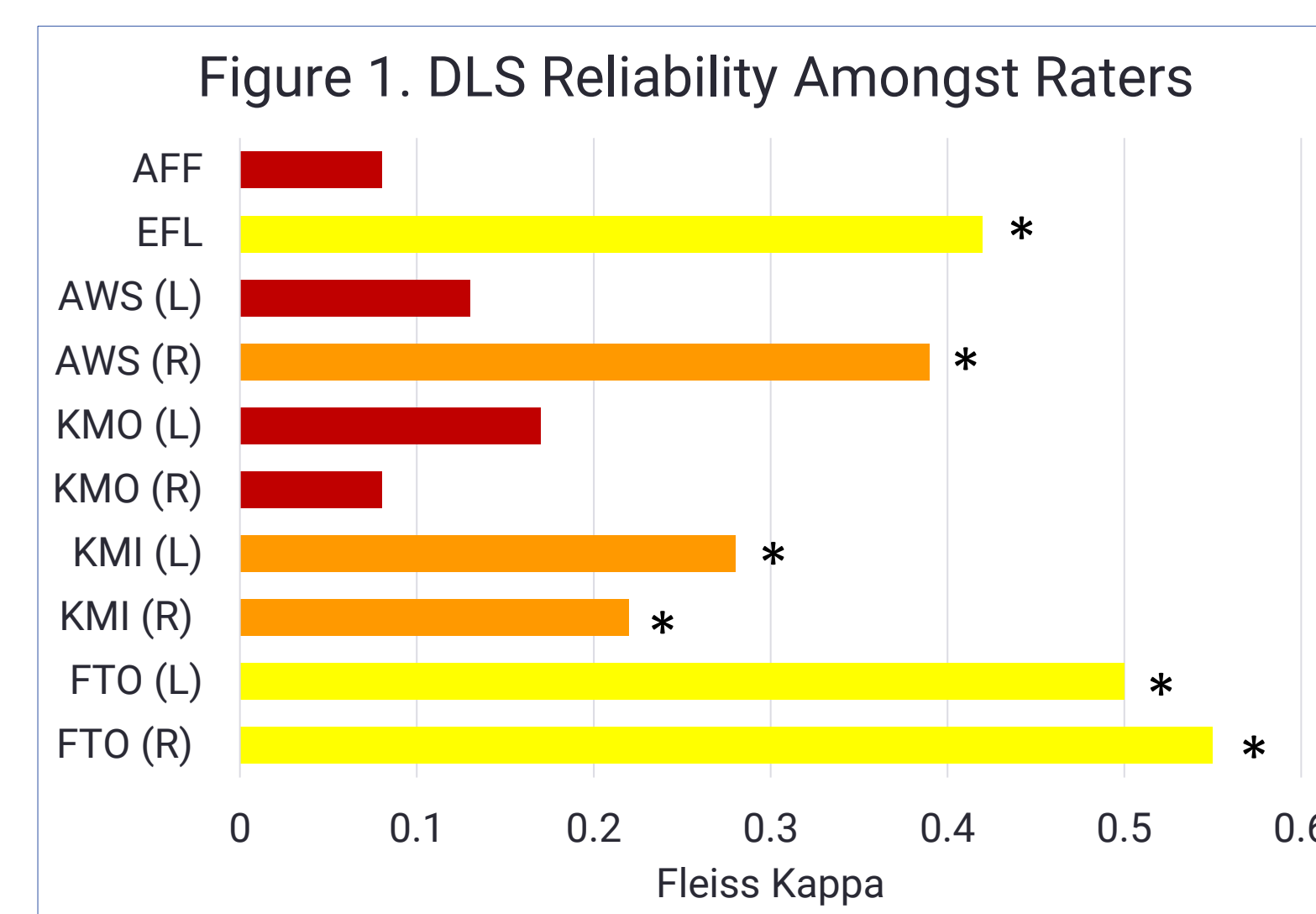


Figure A. Front view of DLS. Figure B. Side view of DLS. Figure C. Right SLS. Figure D. Left SLS.

	Set-Up Instructions	Movement Instructions
Double-Leg Squat (DLS)	Feet shoulder-width apart Toes pointing straight ahead Arms extended directly overhead	"Perform 5 squats as if you are sitting into a chair"
Single-Leg Squat (SLS)	Toes pointing straight ahead Hands on hips Athlete stands on one leg	"Perform 5 squats as if you are sitting into a chair. Go down as low as you feel comfortable."

Movement Compensation	Scoring Criteria
Foot Turns Out (FTO)	Any lateral deviation from the starting position
Knee Moves In (KMI)	Mid-patella moves medial of the first toe
Knee Moves Out (KMO)	Mid-patella moves lateral of the fifth toe
Asymmetrical Weight Shift (AWS)	Lateral deviation of center of mass toward one side
Excessive Forward Lean (EFL)	Inability to maintain torso parallel to tibia
Arms Fall Forward (AFF)	Loss of shoulder flexion in line with torso
Uncontrolled Trunk (UT)	Inability to maintain trunk parallel to the tibia and/or any deviation from starting/neutral position
Loss of Balance (LOB)	Two or more touches with non-involved foot or hopping to retain balance

Fleiss Kappa Value	Strength of Agreement
< 0.20	Poor
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Good



The figures above represent the interrater reliability for the movement compensations (Table 2) observed during the DLS and SLS between raters (Figures 1-2) and between the median scoring of the raters and the automated 2D motion analysis system (Figures 3-4). The bars are color-coded based on Fleiss Kappa interpretation (Table 3), and statistical significance ($p < .05$) is represented with an asterisk sign.

RESULTS

- Strength of agreement between raters was poor to moderate for all scored items of the DLS and SLS.
- Strength of agreement between the raters and the automated 2D motion analysis system was also poor to moderate for all scored items of the DLS and SLS (except for Excessive Forward Lean during the DLS).

DISCUSSION

- Intra-rater reliability for the Fusionetics™ system has been reported as ranging from fair to excellent.⁴ The interrater reliability for this system has not been previously reported in the literature.
- The present investigation on interrater reliability indicates that scoring of the double- and single-leg squat across raters using the Fusionetics™ scoring criteria may be less than acceptable.
- For physical therapists that wish to implement 2D artificial intelligence systems, they should be aware that these methods may evaluate movement differently than the human eye.

ACKNOWLEDGEMENTS

This research trial was approved by the Samaritan Health Services Institutional Review Board (IRB20-075). There was no outside funding for this investigation. Fusionetics™ did not influence the outcomes of this research. We would like to thank the Samaritan Office of Research, Oregon State University Athletics, and the raters who participated in this study for their cooperation and assistance.

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