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3D Joint Kinematic and 2D Quality of Movement Comparison Between Lateral and Forward Step Downs

Samantha Kaye Price
University of Dayton, prices6@udayton.edu

Ryne William Davis
University of Dayton, davisr16@udayton.edu

Andrew Jonathan Hinton
University of Dayton, hintona7@udayton.edu

Jimmy Lee Rowland
University of Dayton, rowlandj2@udayton.edu

David Werner
University of Dayton, dwernerpt@gmail.com

See next page for additional authors

Authors
Samantha Kaye Price, Ryne William Davis, Andrew Jonathan Hinton, Jimmy Lee Rowland, David Werner, and Joaquin Alberto Barrios

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Werner D[1], Price S[1], Davis R[1], Hinton A[1], Rowland J[1], Barrios J[1]

1 – University of Dayton, Department of Physical Therapy

University of Dayton Department of Physical Therapy

UNIVERSITY of DAYTON Motion Analysis Laboratory

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Background

- Step down assessments are frequently used in clinical settings with the lateral step-down (LSD) and forward step-down (FSD) two common variations.
- The LSD and FSD are both reliable and are commonly used for the assessment of lower extremity pathologies such as patellofemoral pain, anterior ligament reconstruction, and femoral acetabular impingement (1-7).
- Step down kinematics can be influenced by reduced dorsiflexion mobility (8).
- Previous studies have demonstrated altered movement quality in those with pathology during either the LSD or FSD (4,7).
- However, no studies have directly compared the lower extremity movement patterns of the FSD and LSD, using either 3-dimensional (3D) joint angle analysis or 2-dimensional (2D) assessment of faulty movement patterns.

Purpose

- To compare 3D and 2D movement patterns of the LSD and FSD in healthy adults.

Hypotheses

- 3D: The FSD will require greater lower limb flexion, potentially eliciting or increasing out-of-plane movements compared to the LSD.
- 2D: The FSD will elicit more faulty movement patterns compared to the LSD.

Participants

- Thirty individuals were recruited from a university setting using electronic advertisements.
- To be included participants were between 18-40 years of age and identified as healthy. Participants were excluded if they had undergone spinal or lower extremity surgery within the last 9 months or had a spinal or lower extremity injury within the last 6 months.

Methods

- All participants provided written informed consent.
- Using a digital inclinometer smartphone application (iHandy Level, IHandSoft inc, NY, USA) ankle dorsiflexion range of motion was measured (Figure 1) (8). The maximum angle was recorded, and three trials were performed and averaged.
- Participants had markers placed on their dominant lower extremity, pelvis, and trunk using an established marker set.
- For the FSD, individuals positioned their toes to the central front edge of the box, holding the non-test limb in front of the box (Figure 2A).
- For the LSD, individuals positioned the medial aspect of their test limb foot along the medial edge of the box, holding their non-test limb off the medial edge (Figure 2B).
- In both tasks, participants lowered the non-test limb heel to tap the floor and returned to the start position for 6 consecutive repetitions at a self-selected pace.
- 3D marker data were collected using an 8-camera motion analysis system (Vicon, Centennial, CO, 100 Hz).

Table 1: Descriptive data as frequency counts or means (standard deviations)

Sex Frequency (M:F)	Dominant Leg (R:L)	Age (years)	BMI (kg/m^2)	Dorsiflexion Range of Motion (degrees)
12:18	25:5	23.5 (1.7)	23.9 (3.3)	42.1 (7.0)

Table 2. Comparison of 3D lower extremity joint angles (degrees) between the LSD and FSD

Variable	LSD	FSD	p-value	Effect Size
Peak Hip Flexion Angle	38.1 (8.5)	36.3 (8.1)	**0.001**	0.22
Peak Hip Adduction Angle	17.1 (4.2)	18.5 (4.0)	**0.006**	0.34
Peak Hip Internal Rotation Angle	1.0 (6.6)	1.2 (6.9)	0.507	0.03
Peak Knee Flexion	56.0 (5.5)	63.1 (4.8)	**<0.001**	1.37
Peak Knee Adduction	2.0 (3.3)	2.0 (3.7)	0.851	0.01
Peak Knee Abduction	-6.0 (5.2)	-6.1 (5.1)	0.549	0.03
Peak Knee Internal Rotation	8.8 (6.6)	9.1 (6.4)	0.376	0.04
Peak Ankle Dorsiflexion	28.3 (4.0)	32.4 (3.8)	**<0.001**	1.03
Peak Ankle Eversion	11.5 (2.5)	12.6 (2.6)	**<0.001**	0.42
Peak Ankle Abduction	15.1 (4.5)	15.4 (4.7)	0.527	0.08

Table 3: 2D video analysis scoring criteria using Modified Piva criteria

Frontal View		
Arm Strategy	Removal of hand from waist	1 point
Pelvic plane	Loss of horizontal plane	1 point
Knee position	Tibial tuberosity medial to 2nd toe	1 point
	Tibial tuberosity medial to medial border of foot	1 point
Steady Stance	Stepping down on non-tested limb or wavering of the tested foot from side to side	1 point
Trunk Alignment	Leaning in any direction	1 point
Lateral View		
Heel Rise	Heel rises off box	1 point
Forward Lean	Ear fully anterior to foot	1 point
Total Possible Points		**8**

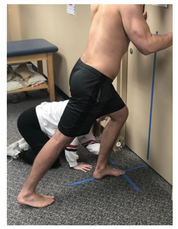

Figure 1: Ankle dorsiflexion range of motion measurement

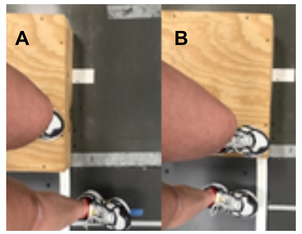

Figure 2: Foot placement for the A) Forward step-down and B) Lateral step-down

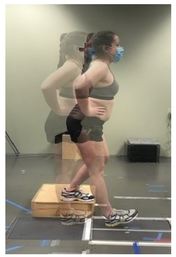

Figure 3: Overlay of forward and lateral step-downs

Table 4: 2D Video Analysis Scoring

	LSD Score			FSD Score			P-value
	Median	Mode	Range	Median	Mode	Range	
Frontal View	2	2	4	2.5	2	3	**0.019**
Lateral View	0	0	1	0	0	2	**0.012**
Combined Views	2	3	4	3	2	5	**0.003**

Methods (continued)

- 3D: The middle 4 repetitions of each task were cleaned and extracted from Vicon Nexus and processed using Visual 3D and custom LabVIEW code.
- 2D: Frontal and lateral view videos were collected concurrently with 3D data using two smartphone cameras (30 Hz, iPhone 7, Apple Inc., Cupertino, CA, USA).
- Videos were assessed by a board certified orthopedic physical therapist using known criteria for the frontal view and novel criteria for the lateral view (Table 3).
- Using an alpha level of 0.05, paired t-tests and Cohen's d effect sizes for paired samples were conducted for the 3D data. McNemar's and Wilcoxon-signed ranks tests were used for the 2D data.

Results

- Descriptive data for all participants is presented in Table 1.
- 3D: The FSD averaged approximately 7° more knee flexion, 4° more ankle dorsiflexion, 1° more hip adduction and 1° more ankle eversion, but 2° less hip flexion than the LSD (Table 2).
- 2D: There were more faults elicited during the FSD than the LSD (Table 4). During the FSD, 24/30 participants demonstrated a fault in steady stance, versus 15/30 during the LSD (p=0.022). 9/30 individuals demonstrated heel rise during the FSD, while 1/30 demonstrated heel rise during the LSD (p=0.021).

Discussion/Conclusion

- The results suggest that the FSD demands greater knee flexion and ankle dorsiflexion at a level that exceeds known minimum detectable differences (9). The remaining significantly different variables were within the error of the measure.
- These findings may suggest that the FSD is a more demanding task than the LSD for patients with reduced tolerance to loaded knee flexion and/or limited ankle mobility.

Clinical Relevance

- Patients with lower extremity conditions may find the FSD to be more challenging than the LSD due to greater flexion requirements, particularly at the knee and ankle.

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