Lower Extremity Sagittal Plane Motion during Different Squat Tasks in Patients with Femoroacetabular Impingement

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INTRODUCTION

Femoroacetabular impingement (FAI) is a condition in which extra bone grows on either the acetabulum or the femoral head. This causes the bones to not fit properly together which can limit the range-of-motion (ROM) that can be achieved by the hip. Biomechanically, squatting is used to replicate daily tasks and can be used to test the overall ROM of the hip and knee joint.[1] The purpose of this study was to determine which squatting technique would elicit the greatest amount of hip and knee ROM and the greatest squat depth for biomechanical assessments. Participants may restrict the depth of their squat to maintain comfort and avoid pain. If squatting is used as a functional assessment or outcome measure, it is important to consider which squat technique elicits the largest amount of hip and knee motion.

METHODS

All participants were enrolled in an IRB approved research study and scheduled to undergo unilateral hip preservation surgery for FAI. Pre-operative kinematic data were collected while participants completed three squatting techniques. During the hold squat, participants were instructed to maintain the squat at their lowest possible position for three seconds. For the standard squat, each participant squatted to their lowest possible position and immediately returned to standing upright. For the target squat, a 15.5cm platform was placed behind the participant who was instructed to attempt to reach but not sit on the platform.[2] Peak sagittal plane kinematics of the trunk, pelvis, hip, knee, and ankle were determined during the squat. Maximum squat depth was calculated by dividing the displacement of the hip joint center (HJC) by the lowest position of the HJC. Parametric statistics were used to evaluate comparisons between squatting techniques for Group 1. A One-way Repeated Measures ANOVA followed by a post-hoc paired t-test was used for comparison of Group 2 ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Forty-six participants that completed the hold and standard squats were included in Group 1 (16.5 $\pm$ 1.7 years, 35 females). Group 2, a subgroup of Group 1, consisted of twenty-five participants (16.5 $\pm$ 2.2 years, 20 females) who completed all three types of squats. The surgical breakdown of Group 2 (21 arthroscopic, 3 surgical hip dislocation, and 1 combined approach) was not as balanced as Group 1 (23 arthroscopic, 22 surgical hip dislocation, and 1 combined approach).

Overall, Group 1 sagittal plane motion of the hip, knee and ankle were significantly different between the two squatting techniques (Table 1). During the standard squat, maximum sagittal plane motion was greater than the hold squat for the hip (4.2°), knee (10.2°) and ankle (1.4°). Maximum squat depth was also greater during the hold squat with participants achieving 12.6% more HJC displacement.

Table 1. Kinematic data of the affected limb of Group 1 during the squatting tasks.

AFFECTED LIMB **Maximum Sagittal Plane Values**	**Group 1** mean (SD)		**Hold vs Standard**
	Hold	**Standard**	***p*-value**
Trunk Tilt (°)	28.5 (12.0)	29.8 (13.2)	0.312
Pelvic Tilt (°)	2.7 (3.8)	2.3 (3.4)	0.062
Hip Flexion (°)	87.7 (14.8)	91.9 (14.1)	**0.005**
Knee Flexion (°)	90.2 (20.6)	100.4 (19.4)	**<0.001**
Ankle Dorsiflexion (°)	32.0 (6.0)	33.4 (5.9)	**0.001**
Squat Depth (%)	36.0 (13.0)	42.6 (12.8)	**<0.001**

Comparing all three squat types, Group 2 showed similar results at the hip, knee, and ankle when comparing the hold and standard squats (Table 2). While the standard squat had increased trunk tilt when compared to the hold squat, the greatest amount of trunk tilt was seen during the target squat. The least amount of squat depth was achieved during the hold squat and the greatest during the target squat.

SIGNIFICANCE

Participants may have restricted the depth of the hold squat to assure comfort and ability as they held the squatting position for three seconds. The amount of joint ROM and overall squat depth noticeably progressed with the deep squat, however, it was greatest in the target squat. Providing a target maximizes overall squat depth which may elicit different mechanics and compensations which may not be present during an untargeted hold or standard squat. Therefore, if biomechanical testing is used as a functional assessment or outcomes measure, a target squat maybe used to achieve the deepest squat and the greatest amount of hip flexion.

REFERENCES

1. Hemmerich, A. et al., (2006). *Journal of Ortho Research*, **24**(4), 770-781.
2. Lamontagne, M. et al., (2009). *Clin Ortho Relat Res*, **467**, 645-650.

Table 2. Kinematic data of the affected limb of Group 2 during the squatting tasks.

AFFECTED LIMB **Maximum Sagittal Plane Values**	**Group 2** mean (SD)			**One-way Repeated ANOVA**	**Hold vs Standard**	**Target vs Hold**	**Target vs Standard**
	Hold	**Standard**	**Target**	***p*-value**	***p*-value**	***p*-value**	***p*-value**
Max Trunk Tilt (°)	27.9 (12.5)	31.5 (12.9)	39.2 (13.8)	**<0.001**	**0.002**	**<0.001**	**<0.001**
Max Pelvic Tilt (°)	2.6 (2.7)	2.2 (2.5)	2.8 (2.6)	0.323			
Max Hip Flexion (°)	87.2 (17.1)	94.5 (14.4)	100.9 (14.4)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Max Knee Flexion (°)	85.0 (18.4)	97.9 (19.7)	108.0 (21.2)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Max Ankle Dorsiflexion (°)	30.4 (5.6)	32.0 (5.5)	29.8 (5.3)	**0.003**	**0.016**	0.403	**0.001**
Max Squat Depth (%)	34.0 (12.0)	42.7 (12.9)	50.4 (14.2)	**<0.001**	**<0.001**	**<0.001**	**<0.001**