The Effects of Different Body Segment Lengths and Heel Lifts on High Bar Squat Mechanics

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Introduction: Squats are a functional movement required for everyday tasks. For proper squat mechanics, the lumbar spine should remain neutral to decrease excessive shear forces. The hips should also be strong, having minimal mediolateral movement in the frontal plane. The tibial angle should be parallel to the upright trunk while the heels are on the ground [4]. However, some common deficits found in squat mechanics include knees over toes, decreased depth, and various ascending or descending speeds of segments that result in increased trunk lean or strain on posterior chain musculature [4]. There have been studies looking at how different segment lengths and the use of a heel lift can both alter normal squat mechanics [3]. Research has shown that as height, segment length of torso, and segment length of trunk increase, it will result in increased maximum knee joint angles [3].

Purpose: To compare how high bar squat mechanics change with flat ground compared to heel lift usage in two individuals of different heights by implementing segment lengths and lower extremity joint angles.

Methods: Before beginning the squat trials, each patient had their torso, femur and stance segment lengths measured. To measure each joint angle of the trunk, hip, knee and ankle joint reflective markers were placed on specific and identical body positions of each individual. The markers were located on the individuals greater trochanter, lateral condyle of the femur, lateral malleolus and second toe. The Hudl app was utilized to capture videos of each participant performing squats with and without a heel lift four times. A screen shot was then taken of each peak or bottom point of the squat. The joint angle was found by placing the axis, stable arm and moving arm on the joint markers of that specific joint being measured. This was repeated four times for both types of squat to find an average angle of each joint (trunk, hip, knee, ankle) per individual.

Results: The individual with shorter segment lengths was found to have a trunk measurement of 39 cm, a femur measurement of 37 cm and squat form with feet 44.2 cm apart. Joint angles for the shorter segment length individual can be seen in Table 1. The individual with longer segment lengths was found to have a trunk measurement of 47 cm, a femur measurement of 43 cm, and a squat form with feet 58.7 cm apart. Joint angles for the longer segment individual can be seen in Table 2. With the heel lift added, flexion decreased at all angles with both individuals as less overall joint range of motion was required. The largest difference seen between individuals was seen at the trunk with the shorter segment individual having more flexion. The shorter segment length individual had a narrower stance during both squat scenarios, therefore compensating with more trunk flexion. Dorsiflexion range of motion decreased with both individuals with the added heel lift. The heel lift resulted in less dorsiflexion needed to achieve a full squat.

Shorter Segment	No Lift	Heel Lift
Trunk	54	46
Hip	69	63
Knee	102	79
Ankle	-15 DF	-10 DF
Longer Segment		
Trunk	39	36
Hip	71	59
Knee	87	75
Ankle	-17 DF	-10 DF

Conclusion: In conclusion, segment length effects squat mechanics and therefore joint stresses. It is important to focus on proper squat mechanics within comfortable limits while being biomechanically conscious. Also, if a patient has less ankle range of motion due to past medical or surgical history, pre-existing conditions or joint hypomobility a heel lift may be a good tool to use due to the fact that the individual would not need as much ankle dorsiflexion range of motion to achieve a squat if a heel lift is in place.

Clinical Implications: Squatting is a functional movement that carries over to activities such as standing up from a chair and sitting down to a chair. Also toileting, transfers and handling household equipment involve squatting. Squatting is a tool used by physical therapists across multiple settings as a therapeutic exercise and it is our responsibility to know the proper form and ways to teach someone how to squat. Along with the proper form, it is important to keep in mind how body composition and biomechanical factors play a role in the mechanics of a squat and how to use tools such as a heel lift can be an important aspect to implement in a squat.

References

1. Demers E, Pendenza J, Radevich V, Preuss R. The effect of stance width and anthropometrics on joint range of motion in the lower extremities during a back squat. *Int J Exerc Sci*. 2018;11:764-775.
2. Lorenzetti S, Ostermann M, Zeidler F, et al. How to squat? Effects of various stance widths, foot placement angles and level of experience on knee, hip and trunk motion and loading. *BMC Sports Sci Med Rehabil*. 2018;10(1):14.
3. McKean MR, Burkett BJ. Does segment length influence the hip, knee and ankle

coordination during a squat movement? *Journal of Fitness Research*. 2012;1:23-30.
4. Myer D, Kushner A, Brent J et al. The back squat: a proposed assessment of functional deficits and technical factors that limit performance. *Strength Cond J*. 2014;36:4-27.