Effect of Heel Lift on Back Squat Biomechanics in Male and Female Resistance Trained Individuals

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Summary

29 male (M) and 29 female (F) resistance trained individuals performing back squats (BS) exhibited less ankle dorsiflexion, hip flexion, pelvic tilt, forward trunk lean, and hip extension moments as well as increased knee flexion and knee extension moments using a heel lift (HL) when compared to without (nHL). Effects were smaller for F than M.

Introduction

Elevating the heel during BS has positive adaptations on BS technique and depth, reducing ankle dorsiflexion (DF) demand thus increasing knee flexion and decreasing forward trunk lean [1,2,3,4]; though, findings are inconsistent [2,5] and possibly effected by sex, training status, and experience. These kinematic changes increase knee extension moments and reduce hip extension moments. Decreased trunk lean is theorized to decrease erector muscle activity and lumbar forces; though experimental results with HL contradict this supposition [2,5]. Inconsistent findings and limited research on HL in BS require additional investigation. The purpose of this study was to investigate the effect of HL on BS biomechanics in M and F resistance trained individuals.

Methods

58 resistance trained individuals (29 M: 21.8 ± 2.0 yrs, 1.80 ± 0.06 meters, 86.5 ± 13.4 kg, 29 F: 22.9 ± 4.5 yrs, 1.66 ± 0.07 meters, 75.9 ± 16.3 kg) completed 5 sets of 3 repetitions of BS while barefoot with and without a 2.5 cm HL and with a 20.4 kg bar (IRB: 434). 61 retroreflective markers created a 9-segment model. 3D motion capture (100 fps) and ground reaction force (2000 Hz) data were collected (Vicon Nexus). Sagittal ankle (θ_A), knee (θ_K), hip (θ_H), pelvis (θ_P), and trunk (θ_{Tr}) angles and knee (M_K) and hip (M_H) moments were calculated (Visual 3D). Angles and moments at the bottom of the BS were analyzed using a two-way (HL x Sex) ANOVA with repeated measures on HL (JASP). $\alpha = 0.05$.

Results and Discussion

θ_A and θ_H increased significantly with HL (Table 1) with a significant HL by sex interaction. θ_A was greater for F than M in the nHL condition suggesting greater ankle dorsiflexion ROM for F. θ_K, θ_P, and θ_T decreased significantly with HL. A significant HL by sex interaction for θ_P and θ_T revealed a smaller effect for F (*d*=0.49 and *d*=0.38) than M (*d*=0.80 and *d*=1.00) for θ_{Pelvis}, and θ_{Trunk} respectively.

M_K increased and M_H decreased significantly under HL conditions. A significant HL by sex interaction indicated a larger, albeit moderate, effect of HL for M (*d*=0.69 and *d*=0.60) than F (*d*=0.31 and *d*=0.45) for M_K and M_H respectively. The smaller effect of HL on θ_P, θ_T, M_K, and M_H for F may be due to greater ankle ROM exhibited by F. This is supported by increased ankle ROM previously observed in female lifters [6] and greater θ_A exhibited by F compared to M under nHL conditions in the current study.

Increases in knee extensor moments and decreases in hip extensor moments with HL is supported by previous work and has muscle recruitment and training implications [1,2,4]. Decreased θ_{Tr} with HL is previously reported [1,2,4] but is not consistently associated with decreases in erector activation or lumbar loading [2,5]. Muscle activity, lumbosacral loading, and prospective training studies are recommended.

Conclusions

Heel lifts increased knee flexion and knee extensor moment and decreased ankle, pelvis, and trunk angles and hip extensor moments in resistance trained individuals. Females exhibited smaller effects using heel lifts than males.

References

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Table 1. Segment and Joint Angles and Moments at Bottom of Squat. Values are Mean (SD).

		θ_{Ankle} (°)*	θ_{Knee} (°)*	θ_{Hip} (°)*	θ_{Pelvis} (°)*^	θ_{trunk} (°)*	M_{Knee} (Nm/kg)*	M_{Hip} (Nm/kg)*
Male	nHL	29.9 (4.4)[1,2]	113.8 (13.4)	108.8 (11.5)	28.5 (11.8)[1,2]	42.8 (9.0)[1,2]	1.42 (0.50)[2]	2.94 (0.90)[2]
	HL	24.0 (3.6)	124.3 (11.9)	106.6 (11.6)	19.5 (10.6)[4]	34.8 (6.9)	1.79 (0.57)	2.46 (0.70)
Female	nHL	34.0 (5.4)[3]	112.4 (13.3)	113.9 (11.7)	37.0 (12.2)[3]	36.5 (8.8)[3]	1.48 (0.52)[3]	2.49 (0.60)[3]
	HL	24.1 (4.9)	118.8 (15.5)	112.9 (12.0)	31.2 (11.3)	33.2 (8.5)	1.64 (0.50)	2.22 (0.61)

Note. Main Effects: *nHL significantly (sign.) different than HL, ^Male (M) sign. different than Female (F). Interactions: [1]F nHL sign. different than M nHL, [2]M nHL sign. different than M HL, [3]F nHL sign. different than F HL, [4]FHL sign. different than M HL. Sign. diff: $p \leq 0.05$.