EFFECTS OF SELECTED UNWEIGHTING CONDITIONS ON KNEE TORQUES DURING PARTIAL SQUATS WHILE TETHERED

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INTRODUCTION

This study examined the effects of different unweighting conditions on the knee torques produced while performing partial squats when tethered by an active traction Conva-Lift prototype.

METHODOLOGY

Six males were unweighted 0%, 25%, and 50% of their body weight (BWT) during a partial squat supported in a Kinney upper body vest by an active traction protoype (Conva-Lift). Reflective markers were placed on the toe, ankle, knee, hip, shoulder, elbow, wrist, and the harness strap. Four partial squats were performed while standing on a Kistler piezoelectric force plate (model 9861A) and videotaped from a sagittal view at 60 fps. The trial representing the most fluid squatting movement was digitized, the joint end points were smoothed with a low pass digital filter at a 10 Hz cut-off frequency and the kinematic variables were analyzed by the Ariel APAS software. The vertical ground reaction forces (GRF) were sampled at 500 Hz. The GRF corresponding to the time of deep crouch which represented the force applied at the foot segment and the unweighting force representing the percentage of the body weight that was applied at the shoulder harness position were entered into the APAS kinetic analysis module, in order to calculate the knee torques at the deepest squat position. From the videographic records the following kinematic variables were calculated: 1) the squat depth (descent), 2) vertical displacement of the center of mass (CM), 3) horizontal displacement of the center of mass, 4) hip angle at deep squat, 5) hip range of motion (ROM), 6) knee angle at deep squat, 7) knee ROM at deep squat, 8) ankle angle at deep squat, 9) ankle ROM, and 10) squat time. An one-way ANOVA with repeated measures on the unweighting factor was used to analyze the kinetic and kinematic data.

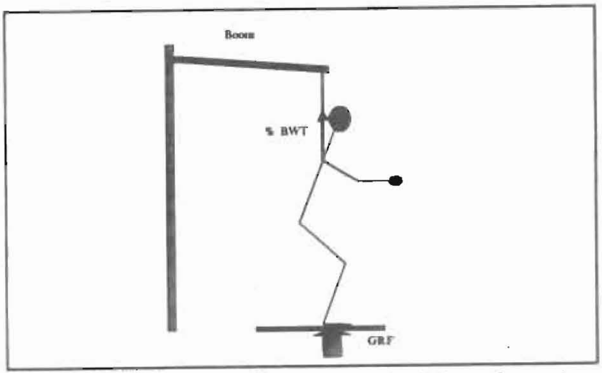

Figure 1 Kinetic model for torque calculation of squat

RESULTS

The subject's mean height was 175.7 ± 10.8 cm, the mean weight was 633.4 ± 151.7 N, and the mean age was 31.2 ± 6.2 yrs. Table 1 provides a summary of the kinematic variable values measured while performing a partial squat under normal BWT, 25% BWT unweighting, and 50% BWTunweighting conditions. The ANOVA analyses performed on the kinematic variables found a significant unweighting condition for the squat depth, CM vertical displacement, CM horizontal displacement, hip angle and ROM, knee angle and ROM, and ankle angle. The Conva-Lift boom arm descended 10.8 cm, 5.3 cm, and 4.6 cm for the normal squat, 25% unweighted, and 50% unweighted conditions, respectively.

The fully weighted squat resulted in a deeper squat than the tethered or unweighted squats. The subjects' CM migration demonstrated a similar vertical descent as the Conva-Lift boom for the 3 weighting conditions as shown in Table 1. When examining the horizontal CM migration during the squatting movement, a greater horizontal (forward) migration was found when squatting untethered. The differences in the horizontal CM migration between the untethered and tethered conditions resulted in a more upright squatting position which was also demonstrated in corresponding changes in the hip angle at deep squat and the ROM of the hip joint during execution of the squat. Also, smaller knee joint angles at deep squat were observed for the fully weighted squat as compared to the unweighted squat. A larger ROM for the knee joint was observed during the deeper squat for the fully weighted condition.

Significantly smaller ankle angles were found for the weighted condition than the unweighted condition which would indicate a greater degree of dorsiflexion while under full body weight. The ankle ROMs during the squatting movement were similar between the three weighting conditions and also, the times required to execute the squat for each unweighting condition were similar.

The analysis found significant differences between the knee torques at deep knee flexion (p=.04) represented in Figure 2, the knee torques were 163.3 ± 50.6 Nm, 106.7 ± 35.7 Nm, and 124.3 ± 26.4 Nm, for the 0%, 25%, and 50% unweighting conditions, respectively.

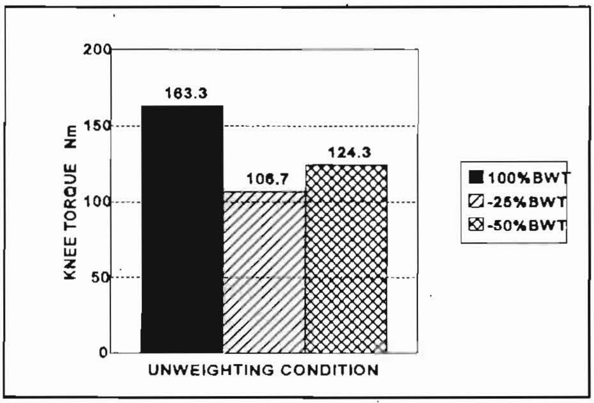

Figure 2 Knee torques during partial squats while tethered

Table 1 Selected Kinematic and Kinetic Variables During Tethered Partial Squats

Variable	Unweighting Condition			
	100%BWT	- 25%BWT	- 50%BWT	F Prob
Squat Depth cm	10.8±3.9	5.3± 1.2	- 4.6± 1.4	p=.003
CM Ver. Displace. cm	-8.4±4.1	-3.7±1.7	-3.5±1.5	p=.001
CM Hor. Displace. cm	5.0±2.2	3.1±2.3	0.8±2.1	p=.005
Hip Angle at Deep Squat deg	133.0±13.4	150.5±7.8	151.6±8.5	p=.005
Hip Angle ROM deg	50.9±7.6	34.2±6.9	29.8±5.9	p=.000
Knee Angle Deep Squat deg	114.1±7.2	135.0±6.5	136.9±6.0	p=.000
Knee ROM deg	50.9±7.6	34.2±6.9	29.8±5.9	p=.000
Ankle Angle Deep Squat deg	82.6±9.6	94.6±11.6	95.7±7.8	p=.000
Ankle ROM deg	21.8±7.9	14.3±3.1	13.6±2.2	p=.501
Squat Time sec	1.6±.26	1.87±.26	1.81±.4	p=.452
Knee Torque Deep Squat Nm	163.3±50.6	106.7±35.7	124.3±26.7	p=.037

These torque values are similar to the values reported by Smidt (1973), and Reilly & Martens (1972), and higher than those reported by Lunnen (1981). The combination of the increased knee flexion and increase knee torque would increase the strain placed on the anterior cruciate ligament (ACL) which would be consistent with the findings of Haynes (1990), and Schilke, Johnson, Housh & O'Dell (1996). Therefore, the reduction of knee torques observed in the tethered conditions would be beneficial in developing quadriceps strength without adversely loading the ACL.

CONCLUSION

In summary, as the degree of unweighting provided by the Conva-Lift active traction prototype was increased, a corresponding decrease in the knee torques was observed. Besides the tethering device reducing the knee torques, it also controlled the depth of squat and these factors would be beneficial in the rehabilitation of knee injuries and preventing further injury.

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