THE INFLUENCE OF SEAT HEIGHT ON SIT TO STAND IN THE ELDERLY: A SIMULATION STUDY

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INTRODUCTION

Lowering seat height has been shown to increase the difficulty of rising from a chair [1]. The impact of this increasing difficulty is particularly important for elderly individuals, because rising from a chair can be a near maximal strength task [5]. Two strategies while in contact with the seat have been proposed for dealing with decreases in seat height: moving the trunk farther forward or increasing the forward momentum of the trunk [9, 7]. The purpose of this study was to examine performance of the sit to stand from progressively lower seat heights, using a validated model of the elderly.

METHODS

The model consisted of three links (shank, thigh, and head arms and trunk). The inertial parameters for the links were the same as those for a typical experimental subject (mean age 71.8 years) from the study of Burgess [2]. The model was actuated by eight muscle models representing the major muscle groups of the lower extremity. Each muscle model had force-length and force-velocity properties as well as activation dynamics [4]. The original parameters values for the muscle model were based on the data in the literature [3, 8], and adjusted to make them reflective of an older subject.

The neural excitations required for the model to perform the sit to stand were determined by solving an optimal control problem. The objective function found the muscle neural excitations required to perform the sit to stand while minimizing the muscle stresses and the rate of change of the muscle forces [6].

The sit to stand was simulated from three different seat heights of 38, 42, and 50 cm. The shank and the trunk were vertical at the start of each of the simulations. Changing seat height was accommodated by rotation of the thigh segment.

RESULTS AND DISCUSSION

The simulation produced a similar kinematics and kinetics as the elderly subjects in Burgess [2]. Trunk movement prior to seat off, as seat height decreased, did not support either of the proposed strategies. The hip angle at seat off increased as seat height decreased. However, because of the higher initial hip angle, the resulting anterior trunk rotation decreased as seat height decreased. Maximum hip flexion velocity also decreased as seat height decreased.

The peak moments required to stand did not necessarily increase as seat height decreased (Table 1). However, if these moments are expressed as a percentage of the moment the muscles are capable of given their current length and velocity then the moments increased as seat height decreased. The maximum knee moment (98 %), and the knee moment at seat off (93 %) for the lowest seat height were close to maximal.

To accommodate the lower seat heights initial hip flexion had to increase. This moved the hip extensors to a less favorable region of the force-length curve. This is complicated by the knee extensors being near maximally stressed at this time, therefore activation of the hamstrings is undesirable. In the simulation from the lowest seat height the gluteal muscles are 90 % activated to reverse the direction of the hip movement, thus not allowing increased forward trunk rotation.

CONCLUSIONS

Two strategies for motion prior to losing contact with seat have been proposed for dealing with decreases in seat height: rotating the trunk farther forward, or increasing the forward momentum of the trunk. Evidence from this study does not support adoption of either of these strategies, because higher initial hip angles during seat contact places great demands on the hip extensors. Clearly decreasing seat height presents a significant challenge to the elderly, with no obvious strategy for meeting this challenge.

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Table 1: The maximum joint moments (as a percentage of maximum moment) during the sit to stand from three seat heights.

	Seat Height		
	38 cm	**42 cm**	**50 cm**
Maximum Hip Extension Moment	70 Nm (67%)	82 Nm (36%)	87 Nm (41%)
Maximum Knee Extension Moment	266 Nm (98%)	271 Nm (96%)	229 Nm (74%)
Knee Extension Moment at Seat Off	245 Nm (93%)	239 Nm (84%)	200 Nm (66%)

Note - Moments presented are for both legs.