Electromyography and leg stiffness comparison between old and young adults in descent stair walking

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INTRODUCTION

Old people experience an increased susceptibility to falls. Four out of five falls on stairs occur in descent stair walking. Descent stair walking challenges elder person's sensoriomotor reaction because it requires the elder person to overcome the perturbation from rapid change in ground reaction force. Initial mechanism of overcoming this perturbation is to adjust leg stiffness rapidly. Intrinsically, muscle activity of the lower extremity must also be alternated. Understanding leg stiffness and muscle activity during descent stair walking for elder person may provide strategy in prevention of fall occurrence. Therefore, the purpose of this study was to investigate the differences in EMG of knee extensors and flexors and leg stiffness between old and young men during descent stair walking.

METHODS

Subjects for the study were 16 old men (72 ± 4.5 years old) and 16 young men (21.2 ± 0.5 years old). Subjects performed one test session of descent stair walking from designed stairs to an elevated force plate. In order to perform quantifiable analysis, the movement was divided into three phases: pre-landing (T_1), impact (T_2), and push-off. (T_3). Electromyograpphy (EMG) signals were recorded from the rectus femoris and biceps femoris of each subject's right leg, while an electrogoniometer measured knee joint angle changes. Leg stiffness was calculated by dividing the first relative maximum of force applied on hip by its corresponding leg displacement. The Student's t-test was used to examine the differences between the two test groups. The significant difference was set at $\alpha < 0.05$.

RESULTS AND DISCUSSION

Table 1 lists the data of all the parameters. During the pre-landing phase, the old subjects were found greater EMG readings for knee extensor muscle control and greater muscle co-contraction. This suggests that the old subjects used greater anticipatory control of the lower limb's muscles to have a safer descent stairs movement. The old subjects had greater leg stiffness at impact phase may indicate that they used a conscious effort to set the limb position prior to impact. This may have helped them anticipate a safer landing, but this posture would result in greater reliance on the skeletal system for impact absorption during landing, and less reliance on the muscles [1]. At push-off phase, in order to decrease sudden ground reaction force applied on the lower extremity, the strategy in old subjects was to increase time in push-off leg. This compensatory mechanism could increase the stability but could also be associated with degradation of muscle strength and slower rate of muscle force production [2].

CONCLUSIONS

Old individuals developed a different strategy for descent stair walking. They relied much more on skeletal system instead of muscle system of the lower extremity to anticipate a safer descent stair walking. The characteristics of their descent stair walking strategy included increased pre-activity and coactivity in thigh muscles at the pre-landing phase; increased leg stiffness at the impact phase; and increased support time at the push-off phase. These changes in mediating leg stiffness and muscle activity might help them anticipate safer descent stair walking.

REFERENCES

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Table 1: Maximal Ground Reaction Forces Applied to the Foot, Leg Stiffness, EMG, and Coactivity Data During Descent Stair Stepping Testing for Older and Younger Subjects

	Phase	Old (n=16)	Young (n=16)	% diff	P
Maximal force, N	-	1291.0	1281.8±0.33	0.72	0.31
Knee flexion angle; deg	T_2	10.6±14.0	19.5±8.2	-45.6	0.01*
Max leg displacement; m	T_2	0.035±0.01	0.065±0.02	-46.2	0.00*
Maximal leg stiffness; kN/m	-	36.8±9.96	21.4±14.8	26.5	0.02*
Knee extensor; %MVC	T_1	24.57±12.02	13.76±5.34	78.6	0.02*
	T_2	38.70±11.49	34.29±11.73	12.3	0.32
	T_3	29.56±7.67	28.02±6.59	5.5	0.57
Knee flexor; %MVC	T_1	23.28±11.86	6.14±2.15	279.1	0.05
	T_2	30.10±8.80	15.49±6.18	94.3	0.83
	T_3	24.31±9.09	14.19±4.82	71.3	0.26
Muscle coactivity;	T_1	1.21±0.71	0.53±0.26	128	0.03*
	T_2	0.87±0.42	0.47±0.21	85.1	0.05
	T_3	0.90±0.47	0.52±0.18	73.0	0.12
Contact time; sec	T_2	0.32±0.03	0.35±0.03	-8.6	0.03*
	T_3	0.72±0.25	0.37±0.06	94.6	0.00*