Influence of handrail use of kinematic effects of ascending and descending stair in old and young age

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Abstract

The present study aimed to examine the influence of handrail use of the kinematic effects of ascending and descending stair in old and young age. A total of thirty-two subjects ascended and descended a purpose-built stair. This experiment conducted to three conditions within no hand, one hand and both hand as use handrails and analyzed gait characteristics. During stair up-down the elderly and young adults generated similar joint movement. However, the difference that noted at hip-rotation between elderly and young adults in case of both hands and one handle use on up-stairs.

Keywords: stairs, older adults, handrails, kinematic effects

1. Introduction

Stairs are frequently encountered obstacles in daily living. Although healthy persons climb stairs quite easily, this movement task is demanding when motor functions are reduced, for example in elderly. It has been reported the joint kinematic during stair descent are similar between young and older adults (Hortiobagyi et al., 2003; Mian et al., 2007). However, the elderly may be operating closer to their maximal joint range of motion limits than young adults. It seems to hypothesize that handrail use will improve safety for older adults on stairs. We hypothesized that use of handrails in older adults would aid dynamic balance control during ascending and descending stairs. This study was to compare lower extremity motion during stair descent and ascend in young and older adults. We focused on descent because it is more challenging than ascent with handrails.

2. Methods

2.1 Participants

Thirty-two healthy subjects, 16 older adults and 16 young persons were tested in this study. None of the subjects reported any neurological, sensor motor or musculoskeletal disorder or deficits, or use of drugs that might affect postural balance, ability to ascend or descend a stairway or ability to grasp a handrail (table 1).

Table 1.

mean± S.D. physical characteristics of older and young

	Old adults	Young adults
	Mean SD	Mean SD
Age(years)	71.39 ± 3.5	23.6 ± 2.6
Height(cm)	167.38 ± 4.319	176.5 ± 6.2
Mass(kg)	65 ± 4.648	71.4 ± 8.8
Right Length(nm)	238.81 ± 10.329	257.8 ± 13.2
foot Width(nm)	91.63 ± 4.241	98.2 ± 4.3

2.2 experimental equipment.

Stairs used to this study were designed to the structure that a handrail was installed as purpose-built stairs. Eight cameras which were arranged around stairs in order to photograph an action of stairs walk were mobilized. A concrete characteristic of stairs and experiment equipment is same as the following (table 2).

Table 2. experimental equipment

Distribution	item.	Contents.
Variable stairs.	High of a stair	20 cm
	Width of a stair	28 cm
	Right and left width of a stair	81 cm
	A number of a stair	6
	High of a handle.	85 cm
	Handle diameter.	3.5 cm
Distribution.	Appliances name.	Manufacture.
Photograph equipment	Hawk.	Motion. Analysis. (USA).
Analysis software.	EVaRT 5.04. OrthoTrak 6.5.1.	

2.3 experimental procedure and analysis method

Participants negotiated a purpose-built of 4-step instrumented staircase. A eight-camera motion analysis system (EVaRT 5.0 Motion analysis, USA) sampling at 60 Hz was used to capture the displacement of reflective markers placed on specific anatomical landmarks of according to the guidelines of the Helen Hayes marker set placement(table 2). This experiment accomplished at three conditions regarding stairs handle. This experiment conducted to three conditions within no hand, one hand, and both hand as

use handrails. Comparisons between Young and old were made using a paired t-test. Data are presented as mean and standard deviation.

3. Results

3.1 Joint angle difference in handrail use of descending and ascending stairs

Average joint angle data are shown in table 3. In frontal plane, no differences were observed in pelvic up/down obliquity, hip ab/adduction, or knee varus valgus and foot progression (table 3). In the sagittal plane, no differences were observed in dorsiplantarflexion, knee flex-extension, hip flex-extension and pelvic tilt. Age-related difference was present in the transverse plane. Internal hip rotation in late stance was greater in older ($t=3.179$, $p<0.05$).

Table 3
mean $\pm$ SD joint angles(in degree) in young and older

Frontal plane			Movement	
	handrail	Age	Ascending	Descending
Foot pro.	No-one	Young	.3.057 $\pm$ 30.133	8.01 $\pm$ 59.984
		Older	10.519 $\pm$ 35.208	68.973 $\pm$ 226.017
	One	Young	-6.815 $\pm$ 24.503	8.671 $\pm$ 38.719
	-both	Older	-.536 $\pm$ 33.022	-11.148 $\pm$ 32.809
Knee Vv	No	Young	2.132 $\pm$ 24.253	-9621 $\pm$ 53.889
	-both	Older	-3.211 $\pm$ 17.134	-1.647 $\pm$ 10.673
	No-one	Young	9743 $\pm$ 12.6448	5.51 $\pm$ 30.128
		Older	-16.611 $\pm$ 48.029	11.349 $\pm$ 37.34
Hip Add.	One	Young	7.144 $\pm$ 29.97	-.016 $\pm$ 15.200
	-both	Older	7.778 $\pm$ 14.352	.515 $\pm$ 13.17
	No	Young	-2.943 $\pm$ 19.124	4.191 $\pm$ 29.335
	-both	Older	-7.024 $\pm$ 12.61	10.697 $\pm$ 37.527
Pelvic Obl.	No-one	Young	2.150 $\pm$ 12.009	-2.293 $\pm$ 18.886
		Older	.568. $\pm$ 24.397	-.365 $\pm$ 20.132
	One	Young	-.843 $\pm$ 13.660	-.489 $\pm$ 23.067
	-both	Older	-9.609 $\pm$ 14.298	-8.231 $\pm$ 18.075
Knee Vv	No	Young	2.246 $\pm$ 22.34	-3.604 $\pm$ 26.336
	-both	Older	-1.012 $\pm$ 15.862	-10.766 $\pm$ 16.131
	No-one	Young	3.272 $\pm$ 21.063	-8.291 $\pm$ 18.886
		Older	-4.707 $\pm$ 10.847	-.354 $\pm$ 26.042
Hip Add.	One	Young	-4.617 $\pm$ 14.798	-3.307 $\pm$ 18.013
	-both	Older	-2.209 $\pm$ 9.97	-.992 $\pm$ 21.35
	No	Young	-.850 $\pm$ 6.995	2.558 $\pm$ 23.919
	-both	Older	109.976 $\pm$ 444.617	-3.173 $\pm$ 25.977
Sagittal plane			Movement	
	Handrail	Age	Ascending	Descending
Dors-P lantar Flextio n	No-one	Young	-1.142 $\pm$ 14.464	5.51 $\pm$ 30.128
		Older	-1.959 $\pm$ 14.041	1.988 $\pm$ 5.968
	One	Young	3.527 $\pm$ 17.194	-.433 $\pm$ 2.914
	-both	Older	1.250 $\pm$ 9.9	-.768 $\pm$ 3.58
Knee flex- Extent ion	No	Young	-4.508 $\pm$ 18.586	1.527 $\pm$ 6.266
	-both	Older	-32.79 $\pm$ 115.573	18.270 $\pm$ 75.537
	No	Young	-.92 $\pm$ 4.974	.707 $\pm$ 4.369
	-both	Older	107.85 $\pm$ 432.695	46.878 $\pm$ 181.522
Hip Flex- Extent ion	One	Young	.065 $\pm$ 5.061	-.832 $\pm$ 3.516
	-both	Older	-.534 $\pm$ 5.233	.91 $\pm$ 3.592
	No	Young	-5.019 $\pm$ 35.297	-.168 $\pm$ 4.818
	-both	Older	5.250 $\pm$ 37.694	49.714 $\pm$ 190.193
Pelvic Tilt	No-one	Young	-.701 $\pm$ 5.529	-3.465 $\pm$ 12.082
		Older	-36.676 $\pm$ 112.455	17.059 $\pm$ 62.829
	One	Young	-3.764 $\pm$ 18.52	3.117 $\pm$ 15.748
	-both	Older	4.807 $\pm$ 11.917	-16.88 $\pm$ 53.259
Knee Flex- Extent ion	No	Young	26.149 $\pm$ 38.98	-1.647 $\pm$ 10.673
	-both	Older	31.306 $\pm$ 71.034	-9.621 $\pm$ 53.889
	No-one	Young	13.495 $\pm$ 60.246	17.596 $\pm$ 43.055
		Older	28.243 $\pm$ 62.364	253.947 $\pm$ 899.046
Hip Flex- Extent ion	One	Young	26.256 $\pm$ 46.567	7.287 $\pm$ 33.334
	-both	Older	5.919 $\pm$ 36.224	.791 $\pm$ 38.436
	No	Young	6.908 $\pm$ 41.463	-.19.878 $\pm$ 50.302
	-both	Older	18.322 $\pm$ 42.859	25.267 $\pm$ 48.568

Transverse plane			Movement	
	handrail	Age	Ascending	Descending
Foot Rotaion	No-one	Young	5.654 $\pm$ 37.093	.479 $\pm$ 16.003
		Older	31.043 $\pm$ 68.215	3.14 $\pm$ 19.822
	One	Young	3.905 $\pm$ 19.463	5.188 $\pm$ 14.005
	-both	Older	-2.431 $\pm$ 9.405	-5.06 $\pm$ 13.248
Knee Rotation	No	Young	-3.312 $\pm$ 26.698	4.61 $\pm$ 14.655
	-both	Older	.604 $\pm$ 30.086	-2.911 $\pm$ 18.278
	No-one	Young	.518 $\pm$ 21.407	-12.493 $\pm$ 26.166
		Older	-6.428 $\pm$ 14.016	1.098 $\pm$ 22.516
Hip Rotaion.	One	Young	2.581 $\pm$ 19.731	2.6 71 $\pm$ 20.563
	-both	Older	4.076 $\pm$ 16.998	-4.915 $\pm$ 11.211
	No	Young	7.264 $\pm$ 26.867	8.01 $\pm$ 59.984
	-both	Older	-10.505 $\pm$ 50.305	68.973 $\pm$ 226.017
Pelvic Rotaion.	No-one	Young	-4.615 $\pm$ 26.67	-.003 $\pm$ 28.083
		Older	2.284 $\pm$ 25.728	-3.356 $\pm$ 18.916
	One	Young	-29.484 $\pm$ 34.188	-16.546 $\pm$ 35.028
	-both*	Older	2.815 $\pm$ 18.764	-5.018 $\pm$ 19.744
Knee Flex- Extent ion	No	Young	-15.369 $\pm$ 58.542	-20.782 $\pm$ 29.559
	-both	Older	-.682 $\pm$ 19.504	-7.985 $\pm$ 27.362
	No-one	Young	23.869 $\pm$ 64.494	-10.847 $\pm$ 33.971
		Older	-2.533 $\pm$ 14.456	27.038 $\pm$ 79.351
Hip Flex- Extent ion	One	Young	2.324 $\pm$ 22.432	1.102 $\pm$ 20.38
	-both	Older	-1.753 $\pm$ 30.58	-2.833 $\pm$ 39.867
	No	Young	.77 $\pm$ 15.294	-14.548 $\pm$ 26.145
	-both	Older	-9.006 $\pm$ 26.438	10.252 $\pm$ 53.045

* $p<0.05$

During stair ascent young and older adults were found to generate similar joint movement but knee and hip joint movements were distributed differently(fig.1) The concept of joint movement being distributed differently between young and older adults(Devita and Hortobagyi, 2000). The older adults reduced the joint movement at the knee but increased the hip movement compared to young adults.

Fig. 1. Joint kinematic demands of stair ascent in young and old adults

During stair descent the knee extension-flexion and ankle dorsiflexion - Plantarflexion angle changes were similar between young and older adults (fig. 2). But foot, knee, hip and pelvic rotation were distributed differently in the stride cycle. Observations of sagittal plane motion older adults include decreased plantarflexion and hip-flex extension at contact relative to young adults. These observations are related to shorten stride in order adults.

Fig. 2. Joint kinematic demands of stair descent in young and old adults

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