EFFECT OF ILLUMINATION ON THE OBSTACLE-CROSSING BEHAVIORS OF ELDERLY WOMEN

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The purpose of this study was to determine how illumination affect elderly women when stepping over obstacles. A motion capture system was used to collect the kinematics data of 15 elderly women. The results revealed that the obstacle-crossing behavior of elderly women were affected by the illumination. Compare to the high illumination condition, the elderly women decreased their toe distance and heel distance ($p<0.05$), increased their foot clearance ($p<0.05$) to avoid connecting with the obstacle, the range of COM (center of mass) was larger. It was concluded that the obstacle-crossing behaviors in elderly varied with the intensity of the illumination.

KEY WORD: illumination, obstacle-crossing behaviors, elderly women

INTRODUCTION: Falls present an important issue on the health of the elderly (Chen et al, 1994). Previous studies rank falls as the fifth leading cause of death among the elderly (Reed-Jones and Solis et al, 2013). Cruz and Ribeiro et al (2012) reported that more than 30% of community-dwelling adults in Brazil aged over 65 years fall every year. DeVito and Lambert et al (1988) indicated that approximately 9,500 of the annual deaths in the United States were related to falls. Yi and Deling (2014) who investigated the fall rate among older adults (over the age of 60 years) in Zhejiang Province, China, revealed that half of the surveyed elderly fell once or more during their daily routines. The major factors of these high fall rates include age, gender, and cardiovascular condition (Ambrose and Paul et al, 2013). Women have a higher tendency to fall (Fuller, 2000) and suffer from greater fall-related damage (Dunlop and Manheim et al, 2002) compared to men. Bergland and Wyller (2004) reported that obstacles and imbalance during gait accounted for nearly 50% of fall-related cases among the elderly. An individual can successfully cross an obstacle by identifying such obstacle at the soonest possible time and by changing his/her walking pattern accordingly (Mohagheghi and Moraes et al, 2004).

Galna and Peters et al (2009) argued that the ability of healthy elderly to discover obstacles was related with their visual–spatial cognition, which could be considerably affected by illumination (Olson and Sivak, 1983). Given that a low illumination delays the input of visual information, the obstacle-crossing behavior of an individual is significantly affected under low lighting (Chapman and Hollands, 2006). Choi and Kang et al (2014) investigated the walking patterns of the elderly and the youth under different lighting conditions and reported that the youths changed their gait pattern under low lighting to walk more safely, whereas the elderly did not. This finding indicates that the elderly are unable to change their gait pattern under changing environments, hence increasing their tendency to fall under low illumination (Pijnappels and Bobbert et al, 2005). The current study aims to determine how illumination affect elderly women when stepping over obstacles.

METHODS: Thirty women with normal body weight was recruited as subjects ([mean ±

standard deviation] age: 65.8 ± 5.6 years; height: 156.6 ± 4.8 cm; body weight: 62.3 ± 8.4 kg; leg length: 75.3 ± 3.6 cm). The trials of this group under high illumination was named GH, whereas their trials under low illumination was named GL. All of the participants were free from cataracts, glaucoma, heart disease, high blood pressure, diabetes, arthritis, cancer, stroke, and other similar pathologies. They likewise have a normal corrected visual acuity. This study was limited to women to avoid gender-related gait differences. All of the participants had signed informed consent forms before participating in the test.

Testing protocol: Laboratory setting: Twenty-seven LED lamps with independent switches were installed on the ceiling of the laboratory to control the illumination. The testing protocol was listed as follows: first, the subjects were given 10 minutes to warm up. Second, a staff member would paste 35 markers on the body of the subjects as instructed by the Vicon system. Third, the illumination was adjusted to > 300 lux (Choi and Kang et al, 2014), and the subjects took a five-minute break to adapt themselves to the new environment (Grue and Ranhoff et al, 2009). Fourth, the subjects wore their own shoes when performing the trials on the walkway (length × width × height of 1,000 cm × 200 cm × 10 cm). The participants approached the obstacles at the most comfortable walking speed. The obstacle is a wood bar (length × width of 200 cm × 2 cm) that is placed on the middle of the walkway. The height of the obstacle is 30% of the leg length of each participant (Zhang and Mao et al, 2011). The obstacle is not fastened to the stand for safety reasons. Therefore, a slight contact will make the obstacle fall down. Each participant was required to finish five trials, and three successful trials were used for analysis. Fifth, the illumination were adjusted to < 10 lux (Choi and Kang et al, 2014), and the subjects are given a five-minute break to adapt themselves to the adjusted laboratory environment. Afterwards, step 4 is repeated.

Data collection: Vicon (Oxford Metrics Limited, type T20S, England) includes eight MX cameras with a sample rate of 100 Hz. A digital light meter (TES, type 1332A, Taiwan) will be used to measure the illumination of the laboratory. An LED light (FSL, type T8, China) with an output power of 12 W will be used as well.

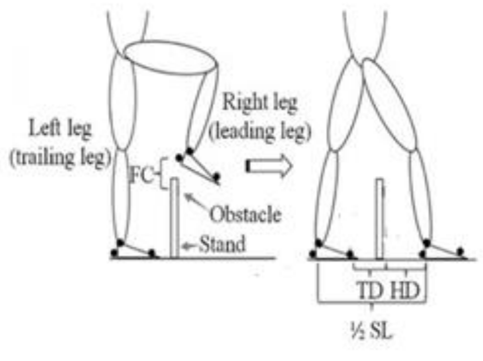

Figure 1: Image representation of the obstacle-crossing variables. SL = stride length; FC = foot clearance; TD = toe distance; HD = heel distance (Zhang and Mao et al., 2011)

Figure 1

Data reduction: (1) Crossing stride length (SL): the stride distance of the leading foot when stepping over the obstacle, as measured by heel placement. (2) Foot clearance (FC): the vertical height between the obstacle and the lowest point of the leading foot when directly over the obstacle. (3) Maximum foot clearance (MFC): the maximum vertical distance between the leading foot and the obstacle when stepping over the obstacle. (4) Toe distance (TD): the horizontal distance between the toe of the trailing foot and the obstacle when crossing the obstacle. (5) Heel distance (HD): the horizontal distance between the heel contact of the leading foot and the obstacle after stepping over the obstacle. (6) Medio–lateral motion range of COM (M–L of COM): the swing range of the center of mass when crossing the obstacle. The TD and HD was normalized to the SL. The FC, M-L of COM and MFC was normalized to the height.

Data Analysis: A pair t-test was used to compare the two conditions (high vs low illumination).

RESULTS: Our research found there were no significant differences between the two groups in SL and MFC (SL: p=1.453; MFC: p=1.731). The TD and HD of GL were smaller compared to the GH (TD: p=0.001; HD: p=0.001). The FC of GL was were larger compared to the GH (p=0.001). The M-L of COM of GL was larger compared to the GH (p=0.001). (Table 1)

Table 1

Kinematics data of elderly women

	GH	GL
Crossing stride length (m)	1.485±0.058	1.417±0.079
Normalized foot clearance (%)	0.258±0.013*	0.250±0.036*
Normalized maximum foot clearance (%)	0.306±0.026	0.298±0.034
Normalized toe distance (%)	0.177±0.047*	0.171±0.064*
Normalized heel distance (%)	0.140±0.011*	0.136±0.018*
Normalized Medio–lateral motion range of COM (%)	0.031±0.001*	0.047±0.003*

*p<0.05

DISCUSSION: The elderly decreased their TD under the low illumination condition, this behavior would increase the odds of striking between the trailing foot and the obstacle when crossing the obstacle. The elderly increased their FC under the low illumination condition, this behavior would decrease the odds of striking between the leading foot and the obstacle when crossing the obstacle. The capability decreased on balance control of the elderly, under the low illumination condition, may lead to the decreasing of HD. The M-L of COM was larger, this data shows that the elderly are easier to fall, under the low illumination condition.

CONCLUSION: The obstacle-crossing behavior of elderly women were affected by the illumination. Under low illumination condition, the elderly will decrease their toe distance and heel distance, increase their foot clearance to step over the obstacle. When step over the obstacle, this behavior will decrease the stability of elderly.

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