Attention and Performance During a Virtual Street Crossing Task in the Elderly Following Orthopedic Surgery Due to Falling

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Key words: Virtual reality, street crossing, elderly, falling, visual-spatial attention

Abstract

Study objectives: The purpose of this study was to describe the use of a virtual street crossing environment among the elderly after an orthopedic operation of the lower extremity due to falling, as compared to a healthy population. Also examined were the relationships between the participants' visual-spatial attention ability and their performance in a virtual street crossing environment, and between their performance in the virtual street crossing environment and during actual street crossing as reported by the participant.

Population: Fifteen healthy elderly adults (mean age = 75.5, SD = 5.4 years) and 15 elderly adults (mean age = 76.1, SD = 4.9 years) who had lower limb orthopedic surgery following a fall were tested.

Instruments: The desktop street-crossing virtual environment (VE) presented a commercial street. Standardized paper and pencil visual-spatial attention assessments were administered. Questionnaires querying participants regarding their perceptions of the VE and their walking and street crossing habits were also administered. Measurements of attention and performance in the VE were gathered at two points in time within a 10-day period.

Results: Significant differences were found between the groups in measures of attention and in performance in the street crossing VE. More than 70% of the patient participants felt that the program helped them to improve their performance during actual street crossing.

Conclusions and treatment implications: A simple desktop VE of street crossing was suitable for use by individuals who are elderly including those who had lower limb orthopedic operation after falling.

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Introduction

The yearly incidence of at least one fall is about 30% for community-dwelling adults over 65 years. About half of these people fall more than once, and about 5% of falls result in a bone or joint fracture (Williams, 2008). The major causes of morbidity include fracture of the hip joint and other immobilizing fractures and soft-tissue injuries that necessitate hospitalization (Chandler & Duncan, 1993). Moreover, the elderly population is the most vulnerable group of pedestrians. In the United States, in 2005, the fatality rate for pedestrians at age 70 years and older was 16 percent (770) of all pedestrian fatalities (National Highway Traffic Safety Administration, NHTSA, 2005).

Attentional reserves are reduced with aging, placing elderly individuals at a heightened risk of falling when they attempt to perform two or more tasks simultaneously, even if the tasks are considered to be automatic or demand minimal attention (Marsh & Geel, 2000). Sparrow, Bradshaw, Lamoureux, and Tirosh (2002) found that among older participants (mean age 71.1), reaction times in the visual and auditory conditions, and in the visual condition solely while walking were significantly longer than for the younger pedestrians (mean age 26.3). Those findings have implications for pedestrian road crossing in which they are required to attend to oncoming vehicles and any other potential hazards at the same time as walking. This can lead to declines in gait task performance and an increased risk of a fall, or alternatively, the allocation of increased attentional resources to the gait task may reduce the response time to a hazard (Sparrow et al., 2002). Reinforcement for these findings are that most elderly pedestrian accidents were due to falls occurred at the time of traversing a road (Abou-Raya1 & Abd ElMeguid, 2009).

Fricke and Unsworth (2001) found that 90.9% of the older people participants (mean age 78.4) indicated that they spend half the day on Instrumental Activities of Daily living (IADL) tasks and the most important IADL was transportation (including driving). Those results confirm the value of IADL to both the occupational therapy profession and older people living in the community (Fricke & Unsworth, 2001). The main role of occupational therapists is to promote the individual's participation in self-defined significant occupations, thus enabling meaningful participation in the tapestry of life (Yalon-Chamovitz et al., 2006).

Therefore, practicing street crossing is an important component of rehabilitation for adults after injury and even for healthy elderly. Practicing street crossing in a VE is especially suited for the practice of a functional task for elderly people, since it enables them to maintain or improve their ability to perform daily tasks that are necessary for a safe, independent life in a protected environment (Weiss, Naveh, & Katz, 2003).

Virtual reality (VR) involves the use of a wide range of computerized technologies that allow for the performance of actions in a simulated environment that encourages participants to behave as they would in an actual environment (Weiss & Jessel, 1998). In a VE one may practice relevant daily tasks free from danger, with control over environmental conditions (Gourlay, Lun, Lee, & Tay, 2000; Wilson, Nigel, & Stanton, 1997). Benefits of VR training programs include the ability to grade the difficulty of a task, thereby adapting it to suit the individual's needs and limitations. Moreover, it provides immediate feedback that contributes to learning without the pressures entailed in real life situations. Thus, VR training programs are considered to be a useful adjunct for clinicians to prepare the individual to perform in complex and dangerous situations (Rizzo & Kim, 2005). Finally, the computerized software of VR programs provides automatic documentation of the progression of individuals through each of the stages of the program, which enables the analysis of their performance (Gourlay et al., 2000; Rizzo, 2002; Rizzo & Kim, 2005). The use of virtual reality technology for assessment and treatment in rehabilitation has increased greatly during the past decade (Weiss, Kizony, Feintuch & Katz, 2006). More recently, applications in occupational therapy are also becoming more common (e.g., Rand, Weiss & Katz, 2009).

In studies of VR in which the elderly participated, positive responses were noted, and results indicated that skills learned in a VE transferred to performance in the real world. For example, Stanton, Wilson, Duffy, and Parnell (2002) examined the transfer of spatial skills among the healthy elderly and younger adults to the real world. The experimental subjects practiced in a virtual shopping center. Participants in the control groups were not given the opportunity to use the VE at all. Two days after practice in the virtual environment, all participants were taken to a real shopping center in order to examine their spatial skills. The two experimental groups (elderly and younger adults) were more precise in choosing goals in a real shopping center as compared to the control groups, and no significant differences were found between the two age groups. The authors' concluded that the use of a virtual environment for the examination of spatial abilities can encourage the healthy elderly to visit large public places (Stanton et al., 2002). Furthermore, good results were also obtained among elderly post-stroke patients with neglect who practiced in a virtual street crossing. Findings demonstrated that their performance could be easily and safely detected and measured via a three-dimensional immersive virtual street crossing program (Kim et al., 2009). Moreover, a non-immersive VR street crossing program that runs on a desktop computer was effective in improving visual-spatial performance and participants' ability to cross an actual street immediately after the VR intervention (Katz, Ring, Naveh, Kizony, Feintuch, & Weiss, 2005). In this era of technology and instrumentation, it is important to examine the suitability and effectiveness of VR as a practice tool for the elderly, whose numbers in the population are steadily increasing.

The objectives of this study were: 1) to compare visual-spatial attention abilities and virtual street crossing performance of elderly participants after an orthopedic operation of the lower extremity due to falling to age-matched control participants; 2) to examine the relationship between measures of visual-spatial attention and performance in a virtual street crossing environment; and 3) to examine whether there was a relationship between performance in a virtual street crossing environment and actual street crossing as reported by the participant.

Methods

Participants

Participants included 30 elderly adults divided into two groups, experimental and control. The 15 experimental subjects, consisting of 6 men and 9 women, ranged in age from 65-83 years (mean = 76.1 years, standard deviation [SD] = 4.9), who had had an orthopedic injury to a lower limb due to falling. The demographic characteristics of both groups are shown in Table 1. Nine of the participants fell in the street and nine of the 15 fell over an obstacle. All of them received in-patient rehabilitation at the "Bet Rivka" Geriatric Rehabilitation Center and, at the time of the study, they were being treated at the Center's day care clinic. All were found to function at a relatively high cognitive level according to their scores on the Mini Mental State Examination (MMSE $\geq$ 24) (Folstein, Folstein, & McHugh, 1975) and at a moderate-high functional level according to their scores on the Functional Independence Measure (FIM) (80-110 out of 126) (Keith, Granger, Sherwin, & Hamilton, 1987). Most of them used a walker or a cane as mobility aids following their surgery and left their homes either independently or under supervision to attend the "Bet Rivka" Geriatric Rehabilitation day program. None of these participants had a history of serious neurological disease, psychiatric hospitalization or serious heart problems.

Fifteen healthy elderly adults (8 men and 7 women) ranging in age from 66-84 years (mean age = 75.5 years, SD = 5.4) participated as control subjects, all with MMSE>24. None had a background of neurological deficits, psychiatric hospitalizations or serious heart problems. Their FIM scores ranged from 100-126, indicating a high functional level, and they were independent in instrumental activities of daily living.

Table 1. Demographic Data

Variable	Experimental group			Control group		
	Mean	SD	Range	Mean	SD	Range
Age	76.1	4.9	65-83	75.5	5.4	66-84
Time between injury and the study (days)	62.7	38.1	35-180			
Yrs. of education	9.6	3.08	5-14	11.9	3.6	5-18

	Experimental group Frequency	Experimental group Percentage	Control group Frequency	Control group Percentage
Gender:				
Women	9	60	7	53.3
Men	6	40	8	46.7
Family status:				
Married	7	46.7	10	66.7
Single	0	0	1	6.7
Divorced	1	6.7	0	0
Widowed	7	46.7	4	26.7
Lives alone	5	33	3	20
Lives with family member	10	67	12	80
Walking aids:				
Walker	8	53.3		
Cane	7	46.7		
None	0	0	15	100
Previous computer Experience:				
None	12	80	11	73.3
Some	3	20	4	26.7

Instruments

1. **A virtual environment for street crossing,** programmed via Superscape's TM 3D-Webmaster, which runs on a Pentium 1 computer (100MHz, 16 MB RAM) with a stereophonic sound card (16 bit) (Katz et al., 2005; Naveh, 2000; Weiss et al., 2003). It is comprised of a typical street with buildings on both sides of the street and flashing street signs. It includes a virtual figure (avatar), which represents the user and is standing on the sidewalk in the middle of the zebra-crossing, ready to cross the street. Users operate a standard keyboard to use the "stop" sign and to look to the left and to the right, in order to indicate when it is safe for the avatar to cross the street. If the avatar is hit by a vehicle, the screeching of brakes is heard and a warning sign appears with the label "accident". Crossing the street successfully causes the program to advance to the next difficulty level. The outcome measures included performance time, number of times looked to the right and left, the number of accidents, stop sign use, and a variable labeled "Time out - Restart", which indicated that more than 2 minutes had passed before an instruction to cross the street was given, and the drill starts from beginning.
2. **Star cancellation subtest of the Behavioral Inattention Test** (BIT), (Wilson, Cockburn, & Halligan, 1987). This subtest of visual-spatial attention is comprised of a page on which 54 small stars (target symbols) are randomly interspersed among a collection of distracter targets that include large stars, letters and words. The subject is asked to draw a diagonal line through all the small stars appearing on the page. Possible scores range from 0-54, with 54 (no omissions) testifying to a high level of attention. Scores indicating normal performance range from 52-54 with a cut-off score of 51 (Wilson et al., 1987). The BIT is a highly valid and reliable standardized test.

   The star cancellation subtest was found to have the highest predictive validity for functional outcome from among all of the BIT subtests among stroke patients (Katz, Hartman-Maeir, Ring, & Soroker, 1999). This was reinforced in the research of Kizony and Katz (2002), who found that visual attention, as assessed in the star cancellation test, is one of the factors that explain 59% of the variability of scores on the Assessment and Motor Process Skills (AMPS) among post-stroke patients.
3. **Mesulam-Weintraub Random Symbol Cancellation Task** (MWCT). (Weintraub & Mesulam, 1985; Weintraub, 2000). This test of visual-spatial

attention is comprised of 4 pages - 2 with symbols and 2 with letters - in organized and random versions. The most sensitive page is the random symbol page, which was used in this study, and includes 60 randomly dispersed target symbols (15 per page quadrant) within a collection of distracters. The subject is asked to draw a diagonal line through each target symbol. Scores indicating normal performance range from 56-60, with a cut-off score of 55 indicating dysfunctional spatial attention (Weintraub & Mesulam, 1985). Adults older than 65 without neurological pathology can complete the test in up to 3 minutes (Weintraub, 2000).

For each of the above two attention tests the number of items cancelled correctly was calculated and the time needed to complete the test was measured.

4. **Virtual Street Crossing Environment Questionnaire** was designed for use in the current study to collect data regarding the perceptions of participants regarding their experience with the virtual street crossing environment program. It is composed of nine statements to be rated on a 5-point Likert scale, including whether they experienced any difficulty or sensitivity (i.e., cybersickness-type side effects) while using the program, whether the program contributed to their self-confidence during actual street crossing, and whether they felt their actual street crossing performance mirrored their performance in the virtual environment program.
5. **Mobility and Street Crossing Habit Questionnaire** is a "yes-no" self-report checklist designed for this study to collect information about the participants' walking and street crossing habits in their daily life, including their independence in mobility, how many times a week they cross the street, whether they leave their homes only during day light or also at night, and whether they feel that the use of the street crossing program helped to improve their actual street crossing. The questionnaire also queried how confident they feel when leaving their homes, how quickly they decide to cross the street, and whether they look a lot of times both ways before crossing the street. The latter answers were rated on a 5-point Likert scale.

Procedure

Data were collected in the Center day care clinic in "Bet Rivka" Geriatric Rehabilitation Center during two 45-minute sessions. During the first session, a demographic questionnaire and the two tests of visual attention were administered to all participants. After this, each participant was introduced to the street crossing VE via a demonstration exercise, and then practiced the VE with increasing levels of difficulty. Later they performed the first VE test, which included 12 different exercises at the same level of difficulty. During the second session, 7-10 days later, the Virtual Street Crossing Environment Questionnaire was administered, the participant was given an opportunity to practice the demonstration VE exercise for 5-10 minutes and then performed the second VE test. Some of the participants needed an additional session to complete all tasks, questionnaires and tests. Approximately two weeks after the second session, the Mobility and Street Crossing Habit Questionnaire was administered to the participant either by telephone or in person.

Data analysis

The data were analyzed using the statistical program SPSS (Version 14). Descriptive statistics were performed on the sample demographics and the virtual reality program data. Independent sample t-tests were used to calculate group differences with respect to the results of the visual-spatial attention assessments and performance on the virtual street crossing program. Pearson correlation analysis was employed to calculate the relationship between the VR data and attentional ability. The correlations between the VR data and street crossing habits were calculated by computing the Spearman or Pearson correlation coefficients, or with the chi square test, as required by the measurement scales. A significance level of 0.05 was used for all tests.

Results

Significant differences were found between the two groups' scores on the MWCT, as well as in performance time on both tests of attention. The healthy elderly had better visual-spatial attention ability and they performed faster than the experimental group. The largest difference found was in their performance on the MWCT (see Table 2).

Table 2. Comparison Between the Study Groups for Visual-Spatial Attention Measures

Variable	Experimental			Control			t	df	(p)
	Mean	S.D.	Range	Mean	SD	Range			
Star cancellation (BIT)									
No. symbols	52.5	1.9	49-54	53.4	0.63	52-54			NS
Performance time (in seconds)	113.2	36.8	54-183	71.8	23.4	37-120	-3.58	27	0.01
MWCT									
No. symbols	57.2	1.85	54-60	59.07	1.1	56-60	3.29	28	0.03
Performance time (in seconds)	240.6	80.6	128-415	117.3	80.9	80-353	-2.15	28	0.04

Note. The maximum score possible on the Stars Cancellation test is 54 and for the Mesulam-Weintraub Random Symbol Cancellation Test (MWCT) is 60. The cut off point for the Stars Cancellation test is 51 and the cut off point for MWCT is 54.

Significant differences were found between the groups for some of the virtual street crossing performance measures. The control group performed more "Time out - Restart" during the first VE test. In addition, the experimental group had significantly more accidents than the control group during the second VE test (see Table 3).

Table 3. Comparison Between the Study Groups on Performance in the Virtual Street Crossing Environment (Test and Retest)

Variable	Experimental			Control			t	df	(p)
First test	Mean	S.D.	Range	Mean	SD	Range			
Total no. Sideway glances	18.8	5.15	11-27	23.4	4.68	15-31			NS
Total no. "Time-Out-Restart"	0.93	1.22	0-3	2.46	2.44	0-7	2.172	28	.042
Total no. accidents	4.2	3.38	0-11	2.8	1.82	0-6			NS
Total no. "stop"	10.66	5.7	4-24	8.13	4.24	3-17			NS
Total time for street crossing (in min.)	13.69	2.8	10.7-20.2	13.25	1.81	11-16.4			NS
Retest									
Total no. sideway glances	19	4.92	11-27	23.26	6.58	11-36			NS
Total no. "Time-Out-Restart"	1.46	1.88	0-5	1.86	1.72	0-6			NS
Total no. accidents	4.2	3.56	0-11	2.13	1.4	0-5	2.086	28	.51
Total no. "stop"	9.6	4.91	4-24	11.8	5.8	5-24			NS
Total time for street crossing (in min.)	12.7	2.43	7.55-17.7	11.73	2.26	7.2-16.16			NS

p=0.05

Moderate positive significant correlations were found between performance time on the MWCT and total time for street crossing on the first VE tests (r=.541, p=.037) in the control group. In addition, for all participants a moderate-low negative significant correlation was found between scores on the MWCT and the total number of times "stop" was pressed during the second VE test (r=.-410, p=.025). Another correlation was found between scores on the MWCT and the total number of sideway glances on the second VE test (r=.404, p=.027).

Results of the Mobility and Street Crossing Habit Questionnaire indicated that participants in the control group were independently mobile and did not use mobility aids, left their homes at all hours of the day or night, and crossed both side and main streets. Participants in the control group left their homes an average of 15.8 times a week (SD=6.4) and crossed the street an average of 19.7 times a week (SD=18.4). They felt very secure when leaving home, decided quickly when to cross the street and looked both ways before doing so with moderate frequency. In comparison, only 40% of the patient group was independently mobile, whereas the remainder required supervision. All but one participant used an assistive device for walking. Only 40% left their homes alone and 64.3% left their home only during daylight hours. Four participants did not cross streets at all and were therefore excluded from the frequencies calculation in Table 4. Of the remaining 26 participants, 36.4% crossed the street alone and 63.6% crossed the street with assistance or accompaniment, 45.5% crossed only side streets and 54.5% crossed busy main streets as well. Participants in the experimental group left their homes an average of 6.6 times a week (SD=6.2) and crossed the street an average of 3.4 times a week (SD=5.0). They had a moderate level of self-confidence when leaving their homes, took a long time to decide when to cross the street and looked both ways infrequently before doing so (see Table 4).

For all participants, positive moderate-low correlations were found between total number of "Time out - Restart" on the first test and the number of times per week that they crossed streets (r=.408, p=.025), and between the total number of times they looked to the sides during the first test and the speed with which they decided to cross a street (r=.421, p=.020).

Table 4. Differences Between Groups in the Walking and Street Crossing Habits Questionnaire

Variable	Experimental		Control		t	(p)
First test	Mean	SD	Mean	SD		
No. times crosses street (weekly)	3.4	5.0	19.7	18.4	3.27	.005
No. times leaves home (weekly)	6.6	6.2	15.8	6.4	3.96	.000
Feels confident when leaving home	3.5	1.9	4.6	1.2	1.85	NS
Making decision to cross the street quickly	0.86	0.5	3.06	1.5	5.26	.000
Looking to the sides a lot when crossing the street	1.2	1.0	2.5	1.2	3.13	.004

Note. Rated from 1-5 (1 =less agreement, 5 =much agreement).

The two groups were similar with respect to how they related to their experience in using the street crossing VE. They agreed that it was very easy to control the VE with the keyboard, that the VE tasks were understandable, and that they behaved in the VE as they do when actually crossing streets. However, the experimental group "very much" agreed that practicing on the computer contributed to their feelings of self-confidence when actually crossing a street, whereas participants of the control group partly agreed with this statement ($t=4.28$, $p=.0001$). Furthermore, with respect to the participants' assessment of the virtual street crossing program, 72.7% of the experimental group felt that using the program helped them prepare to cross an actual street as compared to 26.7% of the healthy elderly group ($Z=-2.29$, $p=.022$).

Discussion

This study examined visual-spatial attention and the use of a virtual street crossing environment among healthy elderly and among elderly individuals who suffered from a hip joint fracture or other lower extremity fractures due to falling. The healthy elderly group demonstrated significantly better attentional abilities than did the experimental group according to their results in the

MWCT, and in performance time on the two tests of attention. The control group also had fewer accidents during the virtual street crossing test, but had more "Time out - Restart" during the first test. Similar findings were found in a study of adolescents aged 13-17 years with Attention Deficit Hyperactivity Disorder (ADHD), who trained using an immersive virtual street crossing environment with a head-mounted (HMD) display. They demonstrated fewer safe behaviors in the virtual environment and had twice the number of accidents in comparison to typical adolescents (Clancy, Rucklidge & Owen, 2006).

The correlations presented above reveal strategies used when performing in a street crossing environment among participants' with high visual attention ability, and which apparently are appropriate for crossing an actual street. That is, they looked to the sides more often to ensure that no cars were approaching, which is why they more often encountered "Time out - Restart" situations, indicating that too much time had passed before they crossed the street and that the drill had to be started again. These findings support those in the literature that describe hesitant behavior, meaning, a greater degree of checking when crossing an actual street, among healthy adult pedestrians, when the number and speed of moving vehicles revealed high risk (Harrel, 1996). In addition, they pressed on the "stop" key less often in the VE, and the general time taken to cross the virtual street and their total performance time was shorter overall in the virtual street crossing test. The experimental group made greater use of the "stop" sign, which constitutes a compensatory strategy that alleviates the complexity of the decision making process in deciding when to cross the VR street, and reduces the need to check for approaching traffic. Oxley, Fildes, Ihsen, Charlton, and Days (1997) suggest that the ability to cross the road efficiently becomes more difficult as age increases, and this is particularly so as the complexity of the task increases. In their study, when pedestrians aged over 65 only had to pay attention to one direction of traffic, they were able to make safe traffic judgments as compared to a complex two-way road situation, which means that older people might experience a reduced capacity to shift attention (Oxley et al., 1997).

The few correlations between VR performance and the Mobility and Street Crossing Habit Questionnaire indicates that participants who crossed an actual street more times per week, reached the "Time out - Restart" situation more often, signifying that it took them more time to decide and that the drill started over again. This finding is supported by findings in the literature that indicates that the time taken to decide whether or not to cross the street is increased among elderly pedestrians aged 75 and over (Oxley, Ihsen, Fildes, Charlton &

Days, 2005), and that their reaction time increases significantly more as the attentional demand grows in comparison to younger persons (Sparrow et al., 2002). When performing in the VR, participants who cross real streets in everyday life behaved with great care, looking to the sides more often, so that the "Time out - Restart" situation was reached. Perhaps this behavior is their way of collecting information on the traffic, and in this way they make the decision to cross the street more quickly than participants who rarely cross real streets in everyday life. In contrast to the results that were expected, the control group members looked to the side, and reached the "Time out - Restart" situation more often. Perhaps they tended to behave more carefully while crossing the street because street crossing was a familiar routine for them. Nevertheless, the total time taken to complete all 12 drills was shorter.

There has been an increase in the number of studies supporting the transfer of skills from virtual environments to the real world for people with cognitive difficulties (Brooks et al., 1999; Gourlay et al., 2000; Stanton et al., 2002), even with the use of the simpler, non-immersive "desktop" virtual environments (Bart, Katz, Weiss & Josman, 2008; Katz et al., 2005). Moreover, McComas, Mackay, and Pivik (2002) demonstrated that even a brief exposure to the program succeeded in teaching children in grades 4-6 the rules necessary for crossing the street, and in improving their tendency to follow safety rules when crossing an actual street. These are important findings that reveal that practice in a VE can be used to teach participants to perform multiple sideways glances and to pause before crossing a street, as they should when crossing an actual street (McComas et al., 2000).

As mentioned previously, the fatality rate in the United States for pedestrians aged 70 years and older is higher than for any other age group (NHTSA, 2005). Crossing a road safely is a complex cognitive task involving a combination of well-developed knowledge and skills, including specific attentional control processes, to assess complex traffic situations and to choose and execute appropriate responses (Oxley et al., 1997). Yet, no studies of road safety education programs for elderly were conducted (Duperrex, Bunn, & Roberts, 2002). Furthermore, only a few studies provided evidence of behavioral change after safety education, and only limited evidence was demonstrated of the effectiveness of safety education in preventing injuries for children (Duperrex et al., 2002). A virtual street crossing environment that incorporates both typical and dangerous situations, as are found in the virtual city environment (McComas et al., 2000) or in the 3-dimensional street crossing environment (Kim et al., 2007), might teach the elderly the rules necessary for crossing the street and encourage them to develop safe street crossing habits. Therefore, training street crossing via a VR simulation could be part of an educational program to prevent accidents among elderly pedestrians and could be used as an educational adjunct for teaching children road safety as well (McComas et al., 2000).

It should be noted that in the current study, all the participants found it easy to understand the rules of the computer program and how to use the keyboard keys, and they seemed to enjoy the exercises even without having had previous computer experiences. In addition, approximately 75% of the experimental group participants felt that the use of the program helped them in crossing an actual street. Furthermore, the results of the Mobility and Street Crossing Habit Questionnaire indicated that 72.7% participants in the experimental group felt that the use of the VR program helped them in crossing actual streets, in contrast to only 26.7% of the healthy elderly. These differences likely resulted from the good street crossing abilities of the control group members in comparison to the experimental group, who were less proficient in this skill.

In summary, the use of a virtual street crossing environment is suited for the healthy elderly as well as for elderly patients who have had lower limb orthopedic operation after falling, as was also found to be true with respect to healthy adults and post-stroke patients (Katz et al., 2005; Weiss et al., 2003). Occupational therapists may use the results of the current study in order to implement the use of this environment into the rehabilitation programs of elderly people. The study results are limited by the modest sample size, and perhaps the wide range of days from injury (35-180) in the experimental group influenced their walking and street crossing habits. In future studies it would be beneficial to collect data of video film of real street crossing. In addition, adding auditory effects could be used to increase the attentional demands, thus perhaps emphasizing the differences between the groups. The potential of virtual street crossing environment to support elderly pedestrian educational safety program should be investigated.

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