

Reliability, Gender Difference, and Relationships among Instruction Patterns of Fall Avoidance Test in Middle-aged and Elderly People

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Abstract To date, few tests have been developed to accurately assess the fall avoidance capability of people. This study aimed to examine reliability, gender difference, and relationships among instruction patterns of the fall avoidance test in middle-aged and elderly people. The subjects comprised of 60 males and 55 females. The touch and step sheets corresponding to the computer screen were placed 10 cm in front and the instruction was demonstrated continuously, randomly displaying a tempo of 30 bpm. Each sheet had to be touched or quickly stepped on depending on the instruction. Three combinations of instruction patterns, which displayed the touch and step six times each, were used. Three trials were performed for each pattern, and the total time of 12 consecutive reaction times was calculated. The intraclass correlation coefficient (ICC) of two approximate values within three trials was very high, demonstrating values ranging from 0.892 to 0.985 in each pattern. The result of the two-way ANOVA (gender x instructed pattern) showed no significant interaction or main effects. The total time of each two instruction patterns mutually showed very high correlation (0.818–0.892) and also a total time of the three patterns (0.931–0.959). Overall, the newly developed fall avoidance test for middle-aged and elderly people has high reliability and no gender difference. The use of the two instruction patterns is appropriate considering the physical burden of the elderly.

Keywords: touch, step, reaction time, elderly

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1. Introduction

With age, various physical functions of middle-aged and elderly people begin to decline; therefore, performing even basic everyday activities, such as walking, becomes difficult and the risk of falling increases [1]. Falls continue to occur despite improvements in related factors, such as physical function or physical illness. Moreover, preventing falls despite sufficient carefulness is complicated due to their unexpected occurrence. To reduce the risk of their falling or prevent serious accidents caused by falls, when they occur, it will be necessary to maintain and improve the ability to avoid falls such as immediately holding a fixed object or instantly taking a step forward, in addition to controlling the decline of physical functions.

Thus far, developing tests (hereafter, the step response

test) to evaluate the fall avoidance ability of the elderly [2] has been attempted. Uchida et al. [3] and Fujitani et al. [4] established a test to evaluate the step reaction ability. Fujitani et al. [4] examined the validity of the step reaction test and reported that the step response in young people was superior to that in the elderly. It was also better in the elderly with regular exercise habit than the elderly without such a habit. Although Uchida et al. [3] and Fujitani et al. [4] focused on the reaction action of the legs, immediately taking one step forward and quickly grasping something, protecting using hands (reaching out) are necessary to prevent the face and thigh from getting hit. Therefore, a test using the combined reaction of arms and legs (not just the legs) is determined to be valid to evaluate the fall avoidance ability. The reliability of the step response test was reported to be high in young people [3] and the elderly [4]. The fall avoidance test using a combination of touch and step is a newly developed approach. Therefore, confirming reliability which is the most important

condition of the new test is necessary.

Nohara [5] reported that regardless of differences in the age level (teens–approximately 50s), jump response times triggered by sound stimuli were shorter in men than in women. Minami et al. [6] indicated that the total body reaction time of the elderly was shorter in males than in females. Jain et al. [7] clarified that the response time of hands triggered by auditory and visual stimuli in young people was shorter in men than in women. The newly created fall avoidance test may also be superior in males to females. If gender differences are found in the test, then establishing evaluation criteria according to gender is necessary. Meanwhile, a usual step reaction test uses five combinations of instruction patterns [3,4]. Only a few trials or patterns are desirable considering the physical and mental burden of the elderly with inferior physical fitness. Examining the relationships among instruction patterns and selecting adequate ones are necessary to reduce their burden.

2. Materials and Methods

1. Subjects

The subjects comprised healthy 60 males and 55 females. The purpose, methods, and risks of the experiment were explained and their consent was obtained. This study was approved by the Ethics Committee on Human Experimentation of Osaka University of Pharmaceutical Sciences (approval number: 0071).

2. Measurement instrument and test

A step measurement system (Takei Scientific Instruments Co., Ltd: S-17189) was used for a test to evaluate the fall avoidance ability (hereafter, fall avoidance test). This measuring device can record time differences between instructions continuously displayed on the screen and reaction action of which hand or foot of the subject contacted the sheet (15 cm in height × 15 cm in width) into a personal computer.

Two sheets were placed on the desk (70 cm high) before the subject (10 cm front) and two sheets with a distance of 40 cm were positioned between their center on the floor. The subjects were asked to stand with an upright posture, placing their weight evenly on both feet. The subjects focused on the laptop screen placed in front and were then instructed to touch or step as quickly as possible following continuous instructions displayed on the screen (Figure 1). Thus, plural combinations of the instruction patterns to demonstrate right/left hands and right/left feet equally are possible.

24 combination instruction patterns which are displayed three times each in advance, were established in this study, and three of 24 patterns were randomly selected (Table 2). The selected tempo of the stimulus presentation was 30 bpm based on the preliminary test. Three trials with at least one-minute intervals were conducted. The order of the three instruction patterns was random to prevent subject prediction. A total of 12 reaction times for touch (6 times) and step (6 times) was calculated in accordance with each pattern. Fujitani et al. [4] reported that the total time of 12 touches and steps was calculated as the reaction time.

3. Analysis method

The reliability of reaction times was examined by the intraclass correlation coefficients (ICC). The mean differences among gender and instruction patterns were examined by the two-way ANOVA (gender × instruction pattern). The relationships among variables were examined by Pearson's correlation coefficient. The significance level in this study was set at $p < 0.05$.

3. Results

Table 3 shows the results of one-way ANOVA and ICC for the reaction time of three trials according to pattern and gender.

Table 4 shows the same analysis results for the mean reaction time of two proximate values. Significant differences among means were not found in any pattern. The ICC of three trials was moderate or high (0.503–0.852) and that of two proximate values was very high (0.892–0.985).

Table 5 shows the results of a two-way ANOVA (gender × instruction pattern) of the mean reaction time considering the above results. No significant interaction or the two main effects was observed.

Table 6 shows the correlation coefficients among reaction times of each instruction pattern, the total reaction time of each two patterns within three patterns, and the total reaction time of the three patterns based on the combined data of male and female. Any coefficient was significant. Each instruction pattern of 1–3 showed moderate correlations mutually (0.492–0.629) but demonstrated high values (0.817–0.842) with the total reaction time of the three patterns. A total reaction time of the two instruction patterns revealed high correlations mutually (0.818–0.892) and very high correlations (0.931–0.959) with that of the three patterns.

Table 1. Basic statistics of age, height, and weight

	male		female	
	Mean	SD	Mean	SD
age(year)	58.3	11.3	58.6	12.2
height(cm)	170.2	5.9	156.9	6.1
weight(kg)	67.3	8.1	50.5	6.9

Table 2. Each instruction patterns

pattern1	left hand	right foot	left foot	right hand	right foot	right hand	left hand	left foot	right hand	left hand	right foot	left foot
pattern2	left foot	right hand	right foot	left hand	left foot	right foot	right hand	left hand	left hand	right foot	left foot	right hand
pattern3	right foot	right hand	left hand	left foot	left foot	left hand	right foot	right hand	left foot	right foot	right hand	left hand

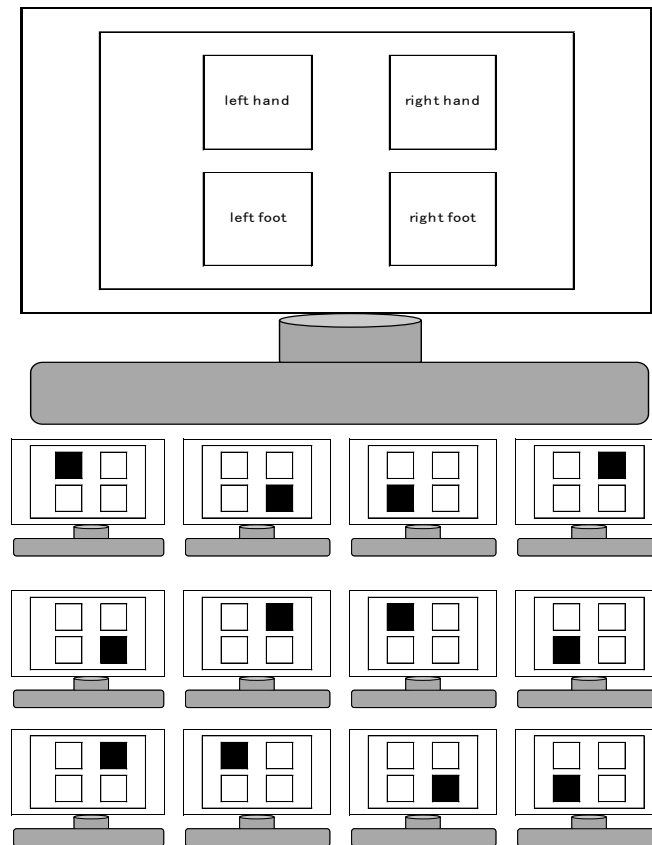


Figure 1. Example of the screen display (pattern1)

Table 3. Results of one-way ANOVA and ICC for the reaction time of three trials according to pattern and gender

		1 trial		2 trial		3 trial		F-value	ICC
		Mean	SD	Mean	SD	Mean	SD		
male	pattern 1 (sec)	10.10	0.78	10.14	0.79	10.15	0.69	0.449	0.792
	pattern2 (sec)	10.22	0.60	10.23	0.72	10.27	0.90	0.144	0.503
	pattern3 (sec)	10.28	0.76	10.25	0.66	10.26	0.71	0.059	0.626
female	pattern 1 (sec)	10.03	0.81	10.14	0.89	10.12	0.87	1.669	0.852
	pattern2 (sec)	10.32	0.82	10.18	0.86	10.17	0.88	1.589	0.669
	pattern3 (sec)	10.13	0.75	10.22	0.86	10.14	0.84	0.421	0.588

Table 4. Results of one-way ANOVA and ICC for the reaction time of two proximate values according to pattern and gender

		proximate 2 values		proximate 2 values		F-value	ICC
		Mean	SD	Mean	SD		
male	pattern 1 (sec)	10.07	0.71	10.11	0.70	2.248	0.968
	pattern 2 (sec)	10.19	0.65	10.19	0.67	0.011	0.898
	pattern 3 (sec)	10.23	0.64	10.24	0.59	0.067	0.892
female	pattern 1 (sec)	10.09	0.90	10.08	0.91	0.024	0.985
	pattern 2 (sec)	10.23	0.86	10.18	0.83	1.912	0.951
	pattern 3 (sec)	10.12	0.72	10.19	0.84	2.340	0.899

Table 5. Results of two-way ANOVA (gender x instruction pattern) of the reaction time

	male		female		F-value	
	Mean	SD	Mean	SD		
pattern 1 (sec)	10.09	0.70	10.09	0.90	F1(gender)	0.042
pattern 2 (sec)	10.19	0.64	10.20	0.84	F2(pattern)	1.682
pattern 3 (sec)	10.23	0.60	10.16	0.76	F3(interaction)	0.227

Note: a reaction time is a mean time of proximate 2 values

Table 6. Correlation coefficients among reaction time of each instruction pattern, the total reaction time of each two patterns within three patterns and the total reaction time of the three patterns

	①	②	③	④	⑤	⑥	⑦
① pattern 1	1.000						
② pattern 2	0.492*	1.000					
③ pattern 3	0.503*	0.629*	1.000				
④ total reaction time of pattern 1 +2	0.878*	0.848*	0.651*	1.000			
⑤ total reaction time of pattern 1 +3	0.889*	0.639*	0.843*	0.892*	1.000		
⑥ total reaction time of pattern 2 +3	0.551*	0.908*	0.897*	0.834*	0.818*	1.000	
⑦ total reaction time of the 3 patterns	0.817*	0.842*	0.839*	0.959*	0.953*	0.931*	1.000

Note: combined data of male and female; * $p < 0.05$

the discriminant and criterion-related validity will be necessary in the future.

4. Discussion

The ICC of the three trials was moderate or higher in male and female and that of two approximate values was 0.8 or higher. Uchida et al. [3] reported that step reaction time in young people was high, ranging from 0.77 to 0.93. Fujitani et al. [4] indicated the high ICC (0.84–0.97) of the elderly's step reaction time. Although the present test used a combination of step and touch motions, the ICC of two approximate values was highly similar to the above-stated reports. Thus, the reliability of the new fall avoidance test for middle-aged and older people is considered to be high.

Gender difference was not found in the reaction time of the three instruction patterns. Nogita et al. [8] examined gender differences in the response time to sound stimuli and reported gender differences in young people but not in the elderly. Chandak & Makwana [9] indicated that the response time to visual stimuli was shorter in middle-aged males than in middle-aged females. Moreover, Tsunoda et al. [10] reported gender differences in simple reaction time of the entire body in older people but not in selection reaction time. Gender difference was also absent in the current fall avoidance test, which used selection reaction time of the combined motions of touch and step. In the case of middle-aged and elderly people, unlike simple reaction time, the selection reaction time may not show gender differences.

Uchida et al. [3] and Fujitani et al. [4] used five instruction patterns in the step reaction test. If numerous trials are conducted for each of the five patterns, then these trials would impose large physical burden on the elderly. This study attempted to select effective instruction patterns by examining the relationships among patterns from some perspectives considering the above discussion. The relationships among the three instruction patterns are considered minimal due to mutually moderate correlations ($r = 0.492$ – 0.629). By contrast, the total reaction time of each of the two patterns within three patterns mutually demonstrated high correlation ($r = 0.818$ – 0.892) and very high correlation ($r = 0.93$ over) with the total reaction time of the three patterns. Therefore, even if either of the two patterns is possible the same evaluation as the three patterns. The use of either two patterns within three patterns is effective considering the physical and mental burden of the elderly.

In case of a new test, in addition to reliability, examining practical validity is also essential. Analyzing

5. Conclusions

This study examined reliability, gender difference, and relationships among instruction patterns of the newly developed fall avoidance test for middle-aged and elderly people, which used three kinds of combination instruction patterns, displaying touch and step thrice each. The following clarifications are presented.

1. The new fall avoidance test has high reliability in males and females and no gender difference.
2. The total reaction times of the two patterns within three instruction patterns were highly correlated with each other and with the total reaction time of the three patterns. Using either of the two instruction patterns is appropriate considering the elderly's burden.

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