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Age and Gender Differences in the Step Test with Stipulated Tempos

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Abstract

This study examined differences in tempos of a step test with a stipulated tempo by age levels and gender. Subjects were 316 healthy males and females in the age range of 10 - 80 years. They performed the step test twice for 20 seconds, stepping alternately while a beeping metronome was adjusted to 40 bpm, 60 bpm, and 120 bpm. It was assumed that if the total time discrepancy between the tempos when the foot was grounded was small, people could adjust their steps to different tempos well. The results of a three-way ANOVA showed a significant age difference at 40 bpm. A multiple comparison showed that the total time discrepancy was smaller in 10 - 50 years old than in 60 - 80 years old in males and females. The total time discrepancy at 40 bpm was larger than that at 120 bpm in 10 - 50 years old, and larger in the order of 40, 60, and 120 bpm in 60 - 80 years old. The total time discrepancy showed insignificant gender differences at all ages and tempos. In conclusion, people over 60 years were less able to adjust their steps to a slow tempo than people younger than 50 years. Further, it was more difficult for people under 60 years to adjust their steps to a slower tempo, and a difference in tempos in people over 70 years largely affected their step movements.

Keywords

Dynamic Balance, Step, Elderly

1. Introduction

Various physical functions including balance, joint use, and strength markedly decrease in old age. This makes walking, which is the most basic life movement, unstable for the elderly, and they are prone to falling. Hence, it

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is very important to prevent decreases in physical functions related to basic life activities and to adequately evaluate their functions [1]. Hill *et al.* [2] and Nakada *et al.* [3] proposed a simple and safe dynamic balance ability test, in which participants repeated a stepping movement in one place. This test is easy for young people, but may be difficult for elderly people with inferior leg strength and balance. Aoki *et al.* [1] examined the difference in the center sway of foot pressure during stepping by age groups and reported that it was larger in those aged 70 years than in younger people. Ohnishi *et al.* [4] examined by age the differences in total trace length, an index of COP sway at 80%, 70%, and 60% of maximum step length (MSL) using the Rapid Step Test. They reported that trace length was longer in elderly people than in young people in all MSL conditions. According to Shin and Demura [5], a time discrepancy in the tempos of the step test is significantly larger in the order of 40, 60, and 120 bpm in the elderly, and this tendency is marked in older age groups. It is assumed that people older than 80 years with inferior leg strength have larger COP sway and time discrepancy in the step test than younger and middle-aged people.

Until now, age differences in the step test with a stipulated tempo had been examined by gender [5] [6]. Shin and Demura [6] reported that a significant time discrepancy in people over 60 years was found only at 40 bpm, and the discrepancy in people over 75 years was larger in females at the other tempos. The discrepancy was also larger for males aged between 60 and 64 years as well as 65 and 69 years. On the other hand, Hirase *et al.* [7] reported that elderly females had better knee extension and dorsum pedis flexion strength regarding body weight than males. In the step test with stipulated tempos, because the one-leg support time becomes longer with a slower tempo, leg strength contributes more to maintaining stable posture. Males and females have different leg strength. Hence, we hypothesize that a gender difference is found in the step test with a stipulated tempo (slow) in the elderly.

This study examined gender differences among different age levels with different tempos of the step test.

2. Methods

2.1. Subjects

The subjects were 316 healthy males and females ranging from 10 to 80 years (each 20 for 10 to 60 years old and each 18 for 80 years old). **Table 1** shows the mean age, height, and weight of each group. Before the experiment, the purpose, methods, and risks were explained to each subject and their consent was obtained. The present protocol was approved by the Ethics Committee on Human Experimentation of the Faculty of Education, Kanazawa University.

2.2. Experiment Equipment and Methods

1) Equipment

A step test with stipulated tempos was performed as follows: subjects stood on a step sheet and stepped while matching the tempo set by a metronome. A 120 bpm tempo resembled walking pace [8]. Tempos of 60 bpm and 40 bpm, which correspond to 1/2 and 1/3 of the tempo of 120 bpm, were selected as slower tempos [5]. The gait analysis meter (Walkway MG-1000, Anima and Japan), which can measure in real time when a subject's right or left foot touches the sheet and leaves the sheet from foot pressure information, was used for the test. The sampling frequency was 100 Hz.

2) Study methods

The subjects had to stand on one leg longer than the other to adjust to a slow tempo. In contrast, when using a fast tempo, the one-leg standing time was shorter because they had to step quickly. A time discrepancy between the tempo and grounded time (when the leg is on the ground) occurred. It was assumed that subjects with a smaller total time discrepancy have superior dynamic balance. The total time discrepancy was selected as an evaluation parameter in this study. Because the number of steps in the stipulated time differs according to each tempo, the total time discrepancy was divided by the total step number for 20 seconds and the values were used as evaluation parameters. The mean of two trials was used as the representative value.

2.3. Data Analysis

Three-way ANOVA (one-factor repeated measures) was used to clarify the mean differences of age, gender, and tempos. When a significant interaction or main effect was found, a Tukey's honestly significant difference

(HSD) test was used for multiple comparisons. The linear or curve regression was calculated to examine the relationship between each parameter and each age group, and the significance of the above coefficients was tested. The level of significance was determined to be 0.05.

3. Results

Table 2 shows the results of three-way ANOVA (age, gender, and tempos) for time discrepancy, and significant interaction was found. A multiple comparison test showed that the 40 bpm time discrepancy was smaller in the 10 - 50 years old than in the 60 - 80 years old in males and females. In addition, tempo factor was significant; the results of multiple comparisons showed that time discrepancy was larger at 40 bpm than at 120 bpm for the 10 - 60 years old, and in the order of 40, 60, and 120 bpm for the 70 - 80 years old in males and females.

Figure 1 plots the mean of time discrepancy of the age levels at each tempo and shows the regression equation. All tempos showed significant linear regressions and intercepts in males and females. In a multiple comparison, the regression coefficients were larger at 40 bpm than at 120 bpm in males and females. In addition, non-significant gender differences were found at all tempos.

4. Discussion

Toyama and Fujiwara [8] reported that a 120 bpm tempo is similar to an adult's walking tempo. The 60 bpm and 40 bpm tempos, which correspond to 1/2 and 1/3 the rate of 120 bpm, were selected as slower tempos in this study [5]. Significant age differences were found in the 40 bpm tempo in males and females, but not in the 60 bpm or 120 bpm tempos. Because the step test with stipulated tempo requires that subjects step with alternate legs while matching each tempo standing on one leg occurs. Thus, when using a slow tempo, the one-leg support time becomes longer, and balance and leg strength largely contribute to the stepping performance. Because the elderly over 60 years tend to be inferior in the above abilities, their stepping performances may be largely affected. The regression coefficient in males and females was significant at all tempos, but larger at 40 bpm than

Table 1. Basic static of Participants age height and weight.

		Age (year)		Height (cm)		Weight (kg)	
		Mean	SD	Mean	SD	Mean	SD
Male	10-year-old	16.8	1.7	171.0	5.2	62.7	5.9
	20-year-old	21.5	1.6	172.9	3.1	66.2	5.4
	30-year-old	34.6	3.4	172.3	5.0	72.2	10.0
	40-year-old	42.9	2.7	172.6	6.3	73.1	10.7
	50-year-old	55.4	2.5	169.0	6.4	64.3	10.4
	60-year-old	66.3	2.3	164.2	4.9	63.2	7.6
	70-year-old	73.8	2.6	166.0	8.0	66.9	9.7
	80-year-old	82.5	3.4	163.3	10.2	58.4	11.0
Female	10-year-old	16.9	2.7	156.3	7.2	50.2	7.5
	20-year-old	20.7	0.9	161.4	4.4	54.5	5.6
	30-year-old	35.3	3.6	160.9	4.3	51.4	5.8
	40-year-old	44.9	3.0	158.4	5.4	55.2	6.3
	50-year-old	55.9	4.5	156.3	5.0	52.9	6.0
	60-year-old	66.1	2.2	151.1	4.7	54.7	8.3
	70-year-old	73.7	2.5	147.6	5.5	51.4	7.8
	80-year-old	82.3	1.9	143.1	5.7	48.4	5.5

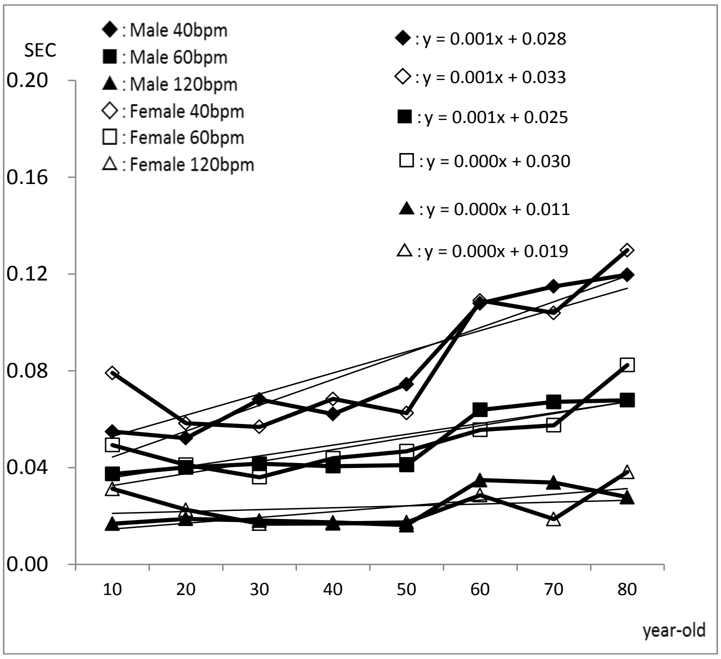

Figure 1. Plot of parameter and regression coefficients.

Table 2. Results of three-way ANOVA (age, gender, and tempo).

		40 bpm (sec)		60 bpm (sec)		120 bpm (sec)			
		Mean	SD	Mean	SD	Mean	SD	F-value	post-hoc
Male	10-year-old	0.05	0.01	0.04	0.01	0.02	0.00	F1 25.15* (7300)	M, F 40 bpm: 10, 20, 30, 40, 50 years old < 60, 70, 80 years old
	20-year-old	0.05	0.02	0.04	0.01	0.02	0.01	F2 0.45 (1300)	M, F 10, 20, 30, 40, 50, 60 years old: 40 bpm > 120 bpm
	30-year-old	0.07	0.02	0.04	0.01	0.02	0.00	F3 540.48* (2600)	M, F 70, 80 years old : 40 bpm > 60 bpm > 120 bpm
	40-year-old	0.06	0.02	0.04	0.01	0.02	0.01	F4 2.49* (7300)	
	50-year-old	0.07	0.04	0.04	0.01	0.02	0.01	F5 8.92 (14,600)	
	60-year-old	0.11	0.04	0.06	0.04	0.03	0.03	F6 0.07 (2600)	
	70-year-old	0.11	0.05	0.07	0.03	0.03	0.02	F7 0.56 (14,600)	
	80-year-old	0.12	0.07	0.07	0.03	0.03	0.01		
Female	10-year-old	0.08	0.05	0.05	0.03	0.03	0.02		
	20-year-old	0.06	0.02	0.04	0.02	0.02	0.01		
	30-year-old	0.06	0.01	0.04	0.01	0.02	0.00		
	40-year-old	0.07	0.02	0.04	0.02	0.02	0.01		
	50-year-old	0.06	0.02	0.05	0.01	0.02	0.01		
	60-year-old	0.11	0.06	0.06	0.03	0.03	0.02		
	70-year-old	0.10	0.04	0.06	0.02	0.02	0.00		
	80-year-old	0.13	0.05	0.08	0.03	0.04	0.02		

*$p < 0.05$, F1: age, F2: gender, F3: tempos, F4: interaction (age × gender), F5: interaction (age × tempos), F6: interaction (gender × tempos), F7: interaction (age × gender × tempos), M: Male, F: Female.

at 120 bpm. In short, the slower tempo showed a larger discrepancy with age. From these results, it is inferred that, as a whole, time discrepancy between tempo and step increases with age in males and females, and it becomes remarkable, particularly in people over 60 years.

The time discrepancy was significantly larger at 40 bpm than at 120 bpm for all age levels in males and females. Because the 120 bpm tempo resembles an adult's walking tempo [8], many people including the elderly could step easily regardless of age. However, one-leg support time becomes longer when the step test uses a slower tempo. Hence, even young people may find it more difficult to step at a 40 bpm tempo than at a 120 bpm tempo. The elderly over 70 years also had a larger time discrepancy at 60 bpm than at 120 bpm. Hence, they may find it more difficult even with a slight tempo difference. It is not easy to repeat step movements while keeping a stable posture in the elderly over 70 years old because of a marked decrease in nerve function and leg strength [3]. Shin and Demura [6] reported that the step movement requires shifting the body's center of gravity to the left or right leg; hence, instability occurs when the body is supported with one leg. The regression coefficient was also significantly larger at 40 bpm than at 120 bpm. In short, time discrepancy with age may be larger at a slow tempo. From the present results, because one-leg support time becomes longer in slower tempos of 40 bpm and 60 bpm, the elderly with inferior balance and leg strength find it difficult to adjust to these tempos, increasing the time discrepancy.

On the other hand, as stated above, strong leg strength is necessary to support the body with one leg for a longer time at a slow tempo. Hirase *et al.* [7] reported that gender differences were found in leg strength of the elderly. Hence, it was hypothesized that gender difference in the elderly during the step test would be found at a slow tempo. However, it was not found in all ages. In short, the hypothesis was rejected. Nisizima *et al.* [9] reported that gender difference was not found in the obstacle walking time of the elderly. Females are inferior in leg strength to males, but are lighter in body weight. Thus, a large gender difference is not found in the burden imposed on the legs during step and walking movements. In short, gender difference in leg strength does not affect either movement.

5. Conclusion

In conclusion, elderly people over 60 years are less able to step while adjusting to a slow tempo (40 bpm) than younger people under the age of 50. It is more difficult, even in those under 60 years, to step while adjusting to slower and different tempos used in the case of elderly people over the age of 70, which largely affects their step movements.

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