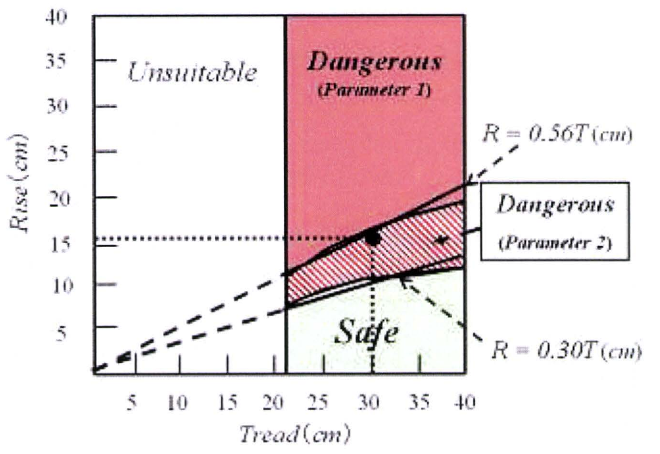

Figure 6 The safe and dangerous dimensions of staircase that was calculated with mathematical model

(● : *The stair dimension used in this study*)

As can be seen from the Figure 6, taking into consideration descending that deviates from the average increases the range judged as dangerous.

4. DISCUSSION

Walking speed and heel clearance were found to be the main effects for both males and females, but the decline in body function with increased age, increased caution during descent, and the corresponding increase in close observation are also considered to have an effect.

The heel trajectories were largely divided into a linear trajectory and a curved trajectory that bulges to avoid the nosing of the stair. All of the heel trajectories were similar to a straight line with a reduction in residual sum of squares accompanying increased walking speed, and the heel trajectory was found to have a greater linear tendency when the descent was quicker, which shows the suitability of this model.

For the parameters entered into this mathematical model, the value obtained by subtracting the standard deviation from the average value was used because of the possibility of the heel hitting on the stairs when walking in a way that even slightly deviates from the average. This parameter used descending conditions that were stricter than the actual conditions to give consideration to foot placement for which the danger rate was increased by 34% from average walking, so if the K value was positive, it could be deemed that the heel would not easily hit using the stair dimensions under consideration.

In addition, since the *c* value changed depending on the tread value, the calculation equation was used to make the parameters the same even when the participants descended stairs with different dimensions [4]. The parameters entered into the model in this way provide a method thought to be reliable in sufficiently considering descending conditions that were stricter than during normal activity.

Figure 5 shows the boundary lines for Parameters 1 and 2 and can quantitatively show the dimensional threshold $R<0.56T$ (cm) that is deemed safe during average descent and the safe dimensional threshold $R<0.30T$ (cm) taking into consideration descents that deviate from the average to create an index useful for preventing falling accidents when descending a stairway.

However, realizing these stair dimensions requires that capacity tolerance be considered, and since it has been reported that falling accidents by tripping on stairs during earthquake evacuation are concentrated among the elderly in Japan, it is desirable that the results from this study be proactively used for the stairs in parks and gymnasiums.

Acknowledgements

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FALL RISK AND COGNITIVE FUNCTION IN OLDER ADULTS: EFFECTS OF AGE AND WORKING MEMORY ON RAPID STEPPING PERFORMANCE

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Abstract: The Rapid Step Test (RST) has been used as an assessment of dynamic balance and fall risk among older adults. The association between higher-level cognitive functions and fall risk has received considerable attention in recent years. This study aimed to examine effects of working memory (WM) capacity on performance of a rapid stepping (RS) task which is a modified version of RST. Healthy younger (n = 11; mean age = 23.2 years) and older (n = 28; mean age = 64.5 years) males performed the RS task. Participants took volitional front, side, and back steps (in total 37 steps) with at least 80% of maximal step length in response to visual commands. Total times required to take 37 steps and stepping error rates were compared as a function of WM capacity which was measured by using the Digit Span (DS) subtest of the Wechsler Intelligence Scale-Third Edition (WAIS-III). There was an effect of WM capacity on RS task stepping errors. The error rate in the older lowest WM quartile (DS subtest raw scores, 6-11) was significantly larger than the error rates of the remaining three older quartiles (DS subtest raw scores, 12-21), as well as that of the younger group (DS subtest raw scores, 12-27), suggesting that individual differences in WM capacity do affect rapid stepping performance. Overall, total times were significantly longer in the older groups than in the younger group, while no significant differences were found among the older quartiles on this variable. The present study demonstrated that older adults whose WM capacity is low (Digit Span subtest raw score < 12) have more difficulties with taking accurate but rapid steps. Furthermore, the Digit Span subtest from the WAIS-III could be a useful independent predictor of fall risk in older adults.

Keywords: cognitive aging, digit span, executive function, risk assessment, older workers

INTRODUCTION

Simple and efficient detection of fall risk among older adults has become a major occupational safety and health research topic as a result of demographic shifts, including a growing number of workers who are over 50 years old. Falls often result in injury and loss of independence in terms of performing everyday activities, and are a leading cause of disability among older adults. Therefore, identifying and understanding the risk factors associated with falls are essential for the development of effective interventions aimed at reducing falls and maintaining independence in older adults.

The Rapid Step Test (RST) is a relatively simple assessment of dynamic balance and fall risk among older adults. The RST requires the ability to execute near-maximal, rapid, consecutive, and volitional steps to the front, side, and back using either foot in response to verbal commands [1]. Medell and Alexander demonstrated that there is a strong correlation between total time required to take 24 steps during the RST and clinical measures of static balance, dynamic balance, and self-reported balance confidence, as well as lower extremity strength output [1].

It has recently been reported that there is a close association between higher-level cognitive functions (executive functions and attention) and fall risk [2-4]. For example, Springer and his colleagues demonstrated that gait of elderly fallers was destabilized during dual task walking, while gait variability of elderly non-fallers or younger adults was not affected by dual task walking [4]. They interpreted these effects as being mediated (in part) by decline in executive functioning, which controls the amount of attention allocated to gait during dual tasking. These results indicate that gait (motor performance) requires attention (i.e., cognitive resources), and that individual differences in cognitive resources might influence motor performance during a physical performance test of fall risk.

To clarify the relationship between cognitive resources and motor performance, we investigated the relationship between working memory (WM) capacity and performance of a Rapid Stepping (RS) task in older adults. WM is one of the most critical aspects of executive functioning. The central executive system of WM is a limited-capacity attentional system that selects goal-relevant behavior by focusing and switching attention [5]. The RS task used here was based on

Medell and Alexander's Rapid Step Test (RST). WM capacity was assessed using the Digit Span subtest of the Wechsler Intelligence Scale-Third Edition (WAIS-III).

The primary purpose of the present study was to examine if WM capacity affects rapid stepping performance in older adults. To detect minimum threshold of WM capacity required for rapid but accurate stepping performance was of interest. To this end, older participants were divided into four quartiles according to their raw scores on the Digit Span subtest. These subgroups consisted of an older Low WM group, an older Middle-Low WM group, an older Middle-High WM group, and an older High WM group. Given previous findings indicating that cognitive resources are related to fall risk, our hypothesis was that motor performance on the RS task would be poorer for the older Low WM group as compared to the older High WM group.

The secondary purpose of this study was to investigate aging effects on rapid stepping performance. RS task performance of the older groups was also compared to that of a younger group. On the basis of the research described previously, we hypothesized that the rapid stepping performance of the older groups would be more impaired than that of the younger group.

METHODS

Participants

Thirty-nine experimentally naïve healthy males participated for paid remuneration. The participants consisted of two groups: A younger group (ranging in age from 18 to 27; mean age = 23.2 years) and an older group (ranging in age from 60 to 69; mean age = 64.5 years).

The older participants were recruited from chapters of the Federation of Senior Citizens in two different cities. Administrators of each chapter selected participants by taking the inclusion criteria into account. The younger participants were recruited from two universities. None of the participants had significant physical, cognitive, or functional impairments. All participants had normal visual fields and normal or corrected-to-normal vision. All participants gave their written informed consent before taking part in this study, which was approved by the Ethics Committee of the National Institute of Occupational Safety and Health, Japan.

Procedure

Each participant completed two test sessions. Functional and neuropsychological assessments were conducted on the first day. The RS task was performed on the second day.

Functional Assessments

Unipedal Stance Test (UPST): The UPST is a simple test for measuring static balance ability. UPST measures the length of time that a participant is able to maintain balance while standing on one leg with their eyes closed. The test was ended if the participant needed support to prevent a fall or was unable to continue. UPST time was measured twice. The longest time of the two was recorded.

Functional Reach Test (FRT): The FRT, a well-established clinical measure of balance, assesses the distance between the length of the outstretched arm and a maximal forward reach from a standing position, with maintenance of a fixed base of support. The longest distance of three trials was recorded.

Knee Extension Strength (KES): KES was measured using a myodynamometer (T.K.K. 5710m, Takei Science Instruments Co., Ltd.). Participants were seated with the hip and the knee joint at 90 degrees of flexion, and then pushed both lower extremities into the device as hard as possible. The highest peak force of two trials was recorded.

Neuropsychological Assessments

Digit Span (DS): The DS subtest of the WAIS-III is composed of both forward and backward recitation conditions [6]. On the digits forward portion of the subtest, the individual is verbally presented with a string of numbers and is asked to repeat back the numbers in order, immediately after stimulus presentation (two trials per item, 2 to 9 digits). In the digits backward condition, the individual is instructed to repeat back the presented string of numbers in reverse order (two trials per item, 2 to 8 digits). The number of correctly remembered trials was recorded for the DS according to the WAIS-III manual (maximum = 16 for the DS forward and maximum = 14 for the DS backward). The DS score combines the total number of digit string trials correctly repeated in both conditions.

Digit Symbol-Coding (DSC): The WAIS-III DSC subtest assesses perceptual and motor processing speed [6]. Participants receive a grid of 133 empty squares with a number (1–9) above each square, as well as a key of symbols that correspond to each number. In 120 s, participants must substitute as many symbols for numbers as possible. For the present analyses, DSC scores were the number of substitutions correctly completed.

Center for Epidemiological Studies Depression Scale (CES-D): The short form of the CES-D is a 20-item questionnaire that assesses depressive symptoms [7]. Participants rate the frequency of their feelings or symptoms over the week preceding the assessment, from

0 (rarely or none of the time) to 3 (most of the time). Higher scores indicate greater depressive symptoms.

Rapid Stepping (RS) Task

Participants were given a few minutes for a cardiovascular and musculoskeletal warm-up prior to the RS task session.

The maximum step lengths (MSL) of each participant to the front, back, and side were determined for each foot by taking the average of five trials in each direction. Participants wore their own running or athletic shoes, and were required to begin each trial from a comfortable position within a starting box, with their arm crossed over their chests. The starting box was a 35.6 cm wide X 30.5 cm long tape rectangle on the floor. As in previous work [1,8], the MSL was defined as the ability to take a single maximal length step out of and then back into the starting box. The base leg had to remain in contact with the floor and not lift off during the step, although the heel was allowed to lift off for front steps. Colored tape was used to mark a line at 80% of the participant's MSL on the floor. These marks served as the targets for the RS task.

Commands for the RS task were given visually on an LCD display located in front of the participant. After the initial command, all successive commands were given using visual images as the participant returned within the starting box from the previous step. Participants were instructed to complete the task as quickly and accurately as possible while keeping their arms crossed over their chest. Each participant performed the same randomized step sequences. After a brief practice session to familiarize the participants with the step target locations and task rules, two sequences of 37 steps were performed. Time to complete the task and error data were both recorded for each sequence. An error was recorded if the participant: (A) did not reach the target line, (B) did not return to the starting box with a single step, (C) uncrossed his arms or lost his balance, (D) stepped with the wrong foot, or (E) stepped in the wrong direction. Inaccurate stepping (not executing a step properly, in terms of foot movements), which did not fall into the five error types just described, was categorized as (F) (an "other" category). A single experimenter visually determined all errors.

Data Collection and Processing

Each foot was initially located on one of two ground-level force plates (9286B, Kistler). All force plate data were sampled at 1000 Hz and were recorded using a computer. Software routines were used to process all data. Total time to complete the RS task was calculated according to data obtained from the two force plates. Step liftoffs from the force plates were indicated by the vertical ground reaction force dropping below 20 N. Step landings on the force plate were determined by the vertical ground reaction force exceeding 20 N. The total time was the length of time that had elapsed since the first step liftoff until the last 37th step landing on the force plate in the starting box.

Statistical Analysis

Participant characteristics are summarized descriptively, using either means and standard deviations, ranges, or frequencies and percentages as appropriate. To explore the impact of WM capacity on rapid stepping performance, the older group was subdivided into four quartiles based on raw Digit Span subtest scores: An older Low group, an older Middle-Low group, an older Middle-High group, and an older High group. Comparisons between groups were performed using repeated measures analysis of variance (ANOVA). The Newman-Keuls test was used for post hoc analyses. A p-value < .05 was considered to be statistically significant.

RESULTS

Table 1 summarizes characteristics of the participants in each of the five groups. ANOVAs were performed on age, height, and weight of participants, with group as a between-subjects factor. There were significant main effects of group on age and height, $F(4, 34) = 683.41$, $p < .0001$ and $F(4, 34) = 4.86$, $p = .0033$, respectively. The main effect of group on weight did not reach significance ($p = .5711$). A post hoc Newman-Keuls test revealed that participants in the older groups were significantly shorter than those in the younger group ($p < .05$). There were no significant height or age differences across the older groups. This analysis confirms that in the older groups, the participants in each subgroup were well-matched in terms of age, height, and weight.

Functional Assessments

ANOVAs were performed on UPST, FRT, and KES scores of participants, with group as the between-subjects factor (see Table 1). There were significant main effects of group on UPST, FRT, and KES scores, $F(4, 34) = 8.34$, $p = .0001$, $F(4, 34) = 9.45$, $p < .0001$, and $F(4, 34) = 8.99$, $p < .0001$, respectively. A post hoc Newman-Keuls test revealed that UPST, FRT, and KES scores in the older groups were all significantly lower than those of the younger group. There were no significant UPST, FRT, or KES differences across the older groups. This analysis confirms that the participants in each older subgroup were well-matched in terms of

Table 1 Participant characteristics

	Older group				Younger group
	Low	Middle-Low	Middle-High	High	
N	7	6	8	7	11
Age (years)	64.3 (1.0)	64.7 (2.0)	64.6 (3.0)	64.6 (1.6)	23.2 (2.4)[d]
Height (cm)	162.7 (7.8)	164.4 (5.4)	165.6 (3.8)	166.4 (7.1)	173.5 (4.4)[d]
Weight (kg)	64.1 (9.8)	68.3 (4.1)	64.5 (7.4)	63.3 (5.4)	67.2 (5.3)
Functional Assessments					
UPST (s)	17.7 (14.5)	9.2 (4.8)	15.6 (19.9)	21.3 (17.5)	126.4 (91.6)[d]
FRT (cm)	30.2 (7.4)	31.4 (4.1)	28.6 (6.7)	35.7 (5.7)	43.6 (5.5)[d]
KES (kg)	66.1 (9.0)	66.6 (11.9)	65.1 (16.6)	62.9 (14.8)	100.4 (21.1)[d]
Neuropsychological Assessments					
Digit Span	8.4 (1.7)[a]	12.2 (0.4)[b]	14.3 (0.5)[b]	17.6 (2.1)[c]	19.5 (5.0)[c]
range	6-11	12-13	14-15	16-21	12-27
DSC	61.4 (19.0)	59.3 (13.2)	64.8 (14.1)	64.0 (10.7)	104.5 (8.9)[d]
CES-D	9.7 (5.6)	7.8 (3.0)	6.1 (4.2)	6.7 (5.5)	5.9 (3.0)

Note. Values are means (*SD*) or ranges. N = Number of participants; UPST = Unipedal Stance Test with eyes closed; FRT = Functional Reach Test; KES = knee extension strength; DSC = Digit Symbol-Coding; CES-D = Center for Epidemiological Studies Depression Scale

[a] The variable in the older Low group was different compared to those in the remaining groups ($p < .05$).

[b] The variables in the older Middle-Low and Middle-High groups were different compared to those in the remaining groups ($p < .05$).

[c] The variables in the older High and younger groups were different compared to those in the remaining groups ($p < .05$).

[d] The variable in the younger group was different compared to those in the older groups ($p < .05$).

UPST, FRT, and KES scores.

Neuropsychological Assessments

ANOVAs were also performed on DS, DSC, and CES-D scores of participants, with group as a between-subjects factor (see Table 1). There were significant main effects of group on DS and DSC scores, $F(4, 34) = 16.43$, $p < .0001$, and $F(4, 34) = 19.88$, $p < .0001$, respectively. There was no effect of group on CES-D scores ($p = .4222$). A post hoc Newman-Keuls test revealed that raw DS subtest scores were lowest in the older Low group, second lowest in the older Middle-Low and Middle-High groups, and highest in the older High and younger groups. Raw DSC scores in the younger group were significantly better than those of each older group. There were no significant DSC score differences among the older groups. The participants in each older subgroup were well-matched on DSC and CES-D scores, but DS score differences were robust.

Rapid Stepping (RS) Task

Total time to complete the RS task and stepping error ratio of each sequence were calculated for each participant. The mean total time as well as the mean percent error for the two sequences were calculated for each participant and then compared across the five groups.

Total Time to complete the RS Task

The mean total time for each group is shown in Figure 1. To examine the effects of aging and WM capacity on RS performance, total task times were analyzed using an ANOVA with group as the between-subjects factor (older Low, older Middle-Low, older Middle-High, older High, and younger group). The main effect of group was significant, $F(4, 34) = 6.83$, $p = .0004$. A Newman-Keuls test revealed that the total time for the younger group was significantly shorter than corresponding times for the older groups ($p < .05$). There were no significant total time differences across the four older groups. Although older participants took more time to complete the RS task than did younger participants, WM differences were not associated with total time required to complete the task for older participants.

Stepping Error Rate

Stepping error rate for the RS task was calculated as the ratio of the number of trials in which a participant stepped inaccurately relative to the total number of trials. Mean error rates for each group are shown in Figure 2. Error rate was analyzed using a between-groups ANOVA. The main effect of group was significant, $F(4, 34) = 6.94$, $p = .0003$. A post hoc Newman-Keuls test revealed that the error rate of the older Low group was significantly larger than corresponding rates for the remaining three older groups, as well as that of the younger group ($p < .05$). Individual differences in WM do appear to be

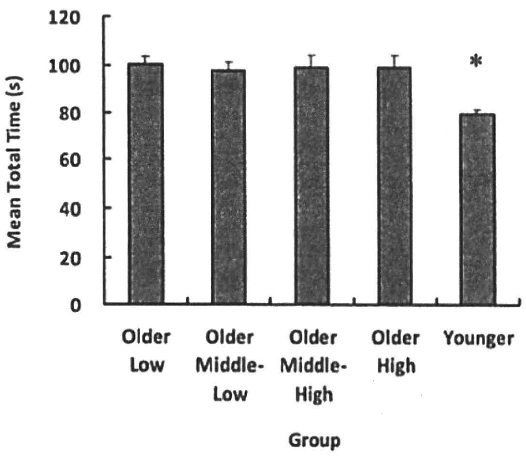

Figure 1 Mean total time to complete the RS task by group. Error bars indicate +1 standard error of the mean. *$p < .05$ from the other four groups

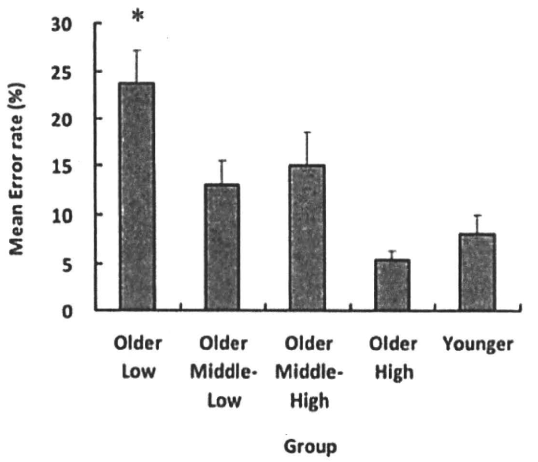

Figure 2 Mean error rates on the RS task by group. Error bars indicate +1 standard error of the mean. *$p < .05$ from the other four groups

Table 2 Mean number of errors occurring during the Rapid Stepping (RS) task

	Older group				Younger
	Low	Middle-Low	Middle-High	High	group
(A) Failure to reach the target line	7.5 (3.8)[a]	3.7 (1.8)	4.3 (2.7)	1.5 (0.8)	2.5 (2.5)
(B) Failure to return to the starting box with a single step	0.5 (0.7)	0.1 (0.2)	0.1 (0.2)	0.1 (0.2)	0.2 (0.4)
(C) Uncrossed his arms or Loss of balance	0.6 (0.4)	0.3 (0.4)	0.1 (0.2)	0.0 (0.0)	0.1 (0.2)
(D) Stepping with the wrong foot	0.1 (0.2)	0.1 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
(E) Stepping in the wrong direction	0.1 (0.2)	0.3 (0.4)	0.9 (1.4)	0.4 (0.4)	0.2 (0.3)
(F) Others	0.0 (0.0)	0.4 (0.5)	0.2 (0.4)	0.1 (0.2)	0.0 (0.1)

Note. Values are means (*SD*).

[a] The variable in the older Low group was different compared to those in the remaining groups ($p < .05$).

related to the stepping errors made by older participants.

Error Analysis

Error types according to the six categories described above were also compared across the five groups (see Table 2). A mixed (5 x 6) factorial ANOVA was conducted with Group (older Low, older Middle-Low, older Middle-High, older High, and younger group) and Error type (A, B, C, D, E, F) as factors. Main effects of Group and Error type were significant, $F(4, 34) = 6.94$, $p = .0003$, and $F(5, 170) = 68.90$, $p < .0001$, respectively. There was also a significant interaction between Group and Error type, $F(20, 170) = 5.16$, $p < .0001$. Significant group differences were found only for Error type A. The number of failures to reach the target line in the older Low group was significantly larger than values for the older Middle-Low, Middle-High, High, and younger groups ($p < .05$). Overall, type A errors were significantly more frequent than the remaining Error types in all groups except the older High group, for which there were no significant differences across the error types.

DISCUSSION

The present study investigated the relationship between cognitive functioning and fall risk in older adults. The main focus was on the possible effects of working memory (WM) capacity on Rapid Stepping (RS) task performance, which captures critical aspects of motor responses to avoid a fall. To accomplish this goal, a group of older participants was subdivided into four quartiles according to their raw scores on the Digit Span (DS) subtest of the WAIS-III, which is conceptualized as a test of WM capacity. These subgroups consisted of an older Low group, an older Middle-Low group, an older Middle-High group, and an older High group. Error rates on the RS task for the older Low group were significantly greater than those of the remaining three older groups, as well as the younger group.

It has been reported that total time or error rate on the RST (Rapid Step Test) are longer or larger in elderly fallers as compared to elderly non-fallers [1]. Static and dynamic balances and lower extremity strength output are associated with RST performance [1]. In this study, we showed that WM capacity is associated with RS task error rates.

An analysis of errors revealed that failures to reach the target line were significantly more frequent in the older Low group, compared to the remaining four groups. Allocation of cognitive resources is a component of the WM executive system [5]. Participants in the older Low group might have had more difficulty paying attention to the target line while performing the RS task, due to lower availability of cognitive resources relative to the other groups.

Total time to complete the RS task was significantly shorter in the younger group than in the older groups, while no significant time differences were found amongst the older groups. This finding is consistent with Medell and Alexander's results [1]. In addition, raw scores on the Digit Symbol-Coding (DSC) subtest of the WAIS-III did not differ across the four older subgroups. DSC scores likely reflect the coordination and speeded performance of a number of uncomplicated scanning, matching and motor operations. Taken together, these findings suggest that differences in WM capacity do not affect speeded performance of these motor operations (i.e., the total time to complete the RS task) for older participants.

None of the measures except for WM capacity in the older Low group differed significantly from those of the remaining three older groups, indicating that individual differences in WM capacity could be one of the key factors related to rapid stepping accuracy. Considering that RST performance does predict fall risk, lower WM capacity could also be a cause of higher fall risk, such that Digit Span subtest raw scores could themselves serve as a useful predictor of fall risk. Raw scores on the Digit Span subtest ranged from 6 to 11 in the older Low group. Although further investigation will be required, the Digit Span cutoff score for fall risk could be set at 11, one standard deviation below normal [6].

In conclusion, the present study demonstrated that individual differences in working memory capacity could affect rapid stepping performance, which is one of the critical protective responses to prevent falls. Working memory-related differences emerged most obviously for rapid stepping accuracy of older adults. In particular, older adults with lower working memory capacity have more difficulties with accurate rapid stepping. Furthermore, the current study suggests that the Digit Span subtest from the WAIS-III could be used as one independent predictor of fall risk in older adults.

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転倒リスクと認知的加齢：作業記憶が急ぎステッピング動作に及ぼす影響[1]

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キーワード：高齢者，認知機能，数唱，歩行，リスク評価

目的

老年期の大きな問題のひとつとなっている転倒の原因として，加齢に伴う身体機能や認知機能の変化があげられる．本研究では，高齢者の転倒リスクと認知機能との関係を明らかにすることを目的とし，転倒しそうになったときの防御反応のひとつである急ぎステッピング動作（Medell & Alexander, 2000）と作業記憶との関係について検討した．急ぎステッピング動作の評価には女性高齢者において転倒との関連性が報告されている Rapid Step Test（RST）を改変した急ぎステッピング課題を，作業記憶の評価にはウェクスラー知能検査（WAIS-III）の下位検査である「数唱」を用いた．

方法

参加者　若年者 11 名（平均年齢 23.2 歳），高齢者 28 名（平均年齢 64.5 歳）．高齢者は「数唱」の素点に基づいて 4 群に分けられた（表 1 を参照）．

表 1　実験参加者の特性　（括弧内は標準偏差を示す）

	若年者	高齢 1	高齢 2	高齢 3	高齢 4
人数	11	7	7	7	7
年齢	23.2	64.6	64.9	64.4	64.3
	(2.4)	(1.6)	(3.2)	(1.9)	(1.0)
数唱	19.5	17.6	14.3	12.4	8.4
	(5.0)	(2.1)	(0.5)	(0.8)	(1.7)

課題　RST を改変した急ぎステッピング課題を用いた．参加者は，前方画面の指示［ステップする足（左／右）と方向（前方／右横／左横／後方）に関する視覚情報］に従い，胸の前で両上肢を交差したまま，最大ステップ長（MSL）の 80%の位置に貼られた目標テープを踏むないしは越えるようにステッピング動作を繰り返した．踏み出した足が所定ボックス内に戻ったと同時に次の指示が前方画面に 1 秒間提示された．1 試行当たりのステッピング動作は 37 回であった．

手続き　参加者はまず MSL を測定した．MSL を左右脚の各方向（前方／右横／左横／後方）につき 5 回ずつ測定し，その平均を MSL の代表値とした．その後，参加者は，急ぎステッピング課題について練習試行を行い，課題のルールに十分慣れた後，本試行を 2 試行実施した．参加者には両足が所定ボックス内に戻ったと同時に提示される指示に従い，できる限り素早くかつ正確にステッピング動作を繰り返すよう教示が与えられた．

[1]本研究の一部は厚生労働科学研究費補助金（課題番号：H21－労働－指定－006）の補助を受けて実施した．

結果

急ぎステッピング課題の（第 1 ステップ開始から第 37 ステップ終了までの）所要時間とエラー率（図 1）を算出し，実験グループ間で比較した．一要因分散分析の結果，エラー率，所要時間ともに実験グループの主効果が有意であった（各々，$F(4, 34) = 6.84, p = .0004$; $F(4, 34) = 6.90, p = .0004$）．下位検定（Newman-Keuls test）の結果，高齢4 のエラー率は他の高齢群に比べて有意に高かった（$p < .05$）．高齢 1，2，3 群と若年者群との間にはエラー率に有意な差は認められなかった．一方，若年者群の所要時間は高齢各群に比べて有意に短かった（$p < .05$）．また高齢各群間では所要時間に有意な差は認められなかった．

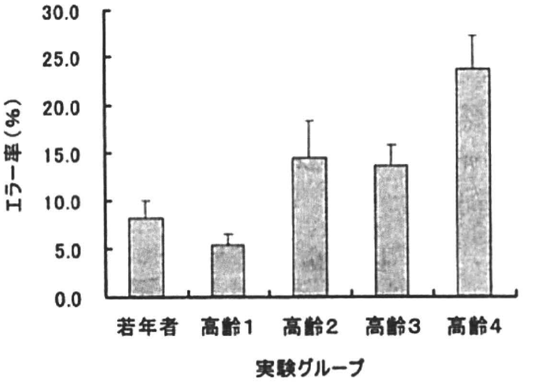

図 1　エラー率（*M+SE*）の実験グループ間比較

考察

急ぎステッピング課題の所要時間とエラー率を実験グループ間で比較し，作業記憶が急ぎステッピング動作に及ぼす影響について検討した．結果，「数唱」の素点が 11 点以下であった高齢者（高齢 4）は，素点が 12 点以上の高齢者（高齢 1，2，3）や若年者に比べて，急ぎステッピング動作のエラー率が有意に高かった．一方，急ぎステッピング課題の所要時間は若年者に比べて高齢者で有意に長かったものの，高齢各群間には有意な差は認められなかった．以上の結果から，「数唱」の素点に反映される作業記憶の違いは転倒しそうになったときの防御反応のひとつである急ぎステッピング動作の正確さに影響を及ぼすことが明らかとなった．特に高齢者において「数唱」の素点が 11 点以下の場合，急ぎステッピング動作の正確さは顕著に低下した．

引用文献

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（いしまつかずま　とうごうふみはる　おおにしあきひろ）

621 年齢，転倒経験，ステップ幅が連続ステッピング動作時の重心動揺に及ぼす影響

Influence of age, falls, and step length on the postural sway during rapid stepping

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This study examined how performance of rapid stepping task related to selected measures of balance and muscle strength. Healthy young (n= 10, mean age = 23 years) and elderly males (n = 28, mean age = 65 years) tested in their ability to take a maximal step to the front, back, and side for each foot (maximum step length (MSL)) and ability to take consecutive rapid steps in the three directions. Target step lengths during the rapid stepping were set to 80%, 70%, or 60% of MSL. Time to complete the rapid stepping and the total length of center of pressure during the test were measured. Balance and strength were studied with peak isometric knee-extension strength, the Functional Reach Test, and 1-legged stance time with eyes close. As a result, we found 1) MSL and performance of the rapid stepping significantly differed between the young and elderly groups, 2) performance of the rapid stepping at any step length did not have significant relationships with any selected measures of balance and strength for the young and elderly groups, 3) performance of the rapid stepping did not differ between elderly fallers and elderly non-fallers, and 4) MSL to the front and side had significant relationships with the knee-extension strength for the elderly group. These results indicate that MSL might be possible to predict knee-extension strength and fall risk for elderly, although performance of the rapid stepping might not.

Key Words : rapid step test, maximum step length, foot center of pressure, fall risk, age effect

A 1．は じ め に

転倒リスクの評価には歩行に見られる重心の移動など日常生活の動作を反映した動的バランス機能を用いることが望ましいとされている。転倒しそうになった時に脚を踏み出してバランスを保持する際に重要となる耐久力・反応力に着目した Medell らは，前後左右の最大一歩幅［Maximum Step Length（MSL）］と MSL の 80%以上の歩幅で指示した方向にできる限り速くステップ動作を繰り返す Rapid Step Test（RST）の成績により，高齢者の転倒リスクを評価できる可能性を示唆した。本研究では Medell らの MSL，あるいは RST を改変した急ぎステップ課題と転倒に関連する身体機能との関係を検討した。また急ぎステップ課題でのステップ幅や転倒経験の有無が急ぎステップ課題の成績に及ぼす影響についても検討した。

A 2．方 法

本研究の参加者は，整形外科的な罹患歴がない若年男性 10 名と高年齢男性 28 名の合計 38 名であった。身体的特性（身長，体重，下肢長），転倒に関連する身体機能（膝伸展力，閉眼片足立ち，ファンクショナルリーチテスト），最大ステップ長（MSL）及び急ぎステップ課題の所要時間と床反力作用点（COP: center of pressure）の総軌跡長を計測した。MSL は，胸の前に両上肢を交差したまま，ある方向（前，後，左，または右）に片足で 1 歩踏み出し，その後，踏み出した足を最初の位置まで 1 歩で戻すことが可能な最大ステップ長とした。急ぎステップ課題では前方に位置するディスプレイ上に提示された指示［踏み出す足（左，または右）と方向（前，左，右，後）がわかる絵］に従ってステップ動作を 37 回繰り返した。ステップ幅は，MSL の 80%，70%，60%の 3 条件を設定した。急ぎステップ課題は各ステップ長につき 2 試行ずつ実施した。

A 3．結 果

身体機能に年齢差が認められた。若年者の膝伸展力，ファンクショナルリーチテスト，閉眼片足立ちの成績は高年齢者と比較して有意に高かった（$p < .05$）。MSL は全ての目標位置において高年齢者よりも若年者が有意に長かった（$p < .05$）。急ぎステップ課題では，若年者の所要時間は高年齢者に比べて有意に短かった（$p < .05$）。また COP 総軌跡長はいずれのステップ幅でも若年者に比べて高年齢者の方が有意に長かった（$p < .05$）。高年齢者について過去 1 年間の日常生活における転倒経験の有無が急ぎステップ課題に及ぼす影響を検討した結果，所要時間，COP 総軌跡長のいずれにおいても転倒経験の有無による有意な差は認められなかった（$p > .05$）。さらに急ぎステップ課題の所要時間あるいは COP 総軌跡長と身体機能との間には若年者，高年齢者どちらにおいても有意な関係は認められなかった（$p > .05$）。一方，高年齢者では，前あるいは横方向の MSL と膝伸展力との間に，有意な正の関連性が認められた（$p < .05$）。

A 4．考 察

本研究では，MSL 及び急ぎステップ課題と転倒に関連する身体機能との関係，ならびに高年齢者の転倒経験の有無が MSL や急ぎステップ課題の成績に及ぼす影響を検討した。その結果，転倒に関連する身体機能といわれている下肢筋力（膝伸展力），静的バランス機能（閉眼片足立ち），動的バランス機能（ファンクショナルリーチテスト），MSL，急ぎステップ課題の成績（所要時間，COP 総軌跡長）に加齢の影響が認められた。一方，高年齢転倒非経験者と高年齢転倒経験者との間では身体機能，MSL，MSL の 80%，70%，60%のステップ幅での急ぎステップ課題の成績に差は認められなかった。ただし，高年齢者では，前と横方向の MSL は膝伸展力と有意な正の関係が認められた。

以上より，急ぎステップ課題を用いて高年齢者の転倒リスクを評価することは困難であると考えられた。一方，前あるいは横方向の MSL は高年齢者の下肢筋力を反映する指標，あるいは下肢筋力に関連する転倒のリスク評価指標となりうる可能性が示唆された。

1. は じ め に

転倒リスクの評価法の 1 つである閉眼片脚立ちテストは下肢の筋力や平衡機能等を反映した有効な指標としてこれまで高齢者を対象として多くの場面で用いられてきた(1)。しかしながら，静止立位を持続するという状況は日常生活場面では少ないため，重心の移動を伴う歩行やイスからの立ち上がりといった日常生活場面に多い動作中のバランス機能（動的バランス機能）の評価の方が転倒リスクの評価には望ましいとされている(2)-(3)。

Medell ら(4)は転倒しそうになった時に脚を踏み出してバランスを保持する際に重要となる耐久力・反応力に着目し，前後左右の最大一歩幅[Maximum Step Length（MSL）]と MSL の 80%以上の歩幅で，指示した方向にできる限り速くステップ動作を繰り返す Rapid Step Test（RST）を用いて，高齢者の転倒リスクを評価できる可能性があることを示唆している。彼らは，バランス機能が劣っている高齢者はそうでない高齢者と比較して MSL が短い，RST の所要時間が長い，と報告している(4)。さらに MSL あるいは RST の所要時間は開眼片足立ちや下肢筋力等と有意な相関があるとも報告している (4)。しかしながら，解析の対象者には若年者と高齢者が含まれ，いずれの評価値にも存在する加齢の影響は調整されていない。したがって，MSL あるいは RST の成績と関連する身体機能（とくに転倒に関連するもの）は明らかではない。

そこで本研究では，MSL あるいは RST の成績は，どのような身体機能と関連するのか，また高年齢者の転倒経験の有無を反映するのかを調べた。なお RST については，ステップ動作の指示の手法やステップ回数を Medell らの方法から変更した課題（急ぎステップ課題）を用いた。さらに急ぎステップ課題では，Medell らの方法で用いられている MSL の 80%の歩幅に加え，MSL の 70%，60%の歩幅でのステッピング動作についても検討した。

2. 方 法

2・1. 参加者

本研究には腰痛あるいは整形外科的罹患歴のない若年男性 10 名，高年齢男性 28 名の合計 38 名が参加した（Tab.1）。参加者は，研究内容及び実験で起こり得る危険性とその安全対策について，口頭及び書面によるインフォームドコンセントを受け，同意した上で本研究に参加した。なお，本研究は独立行政法人労働安全衛生総合研究所研究倫理委員会の承認を得ている。

2・2. 手続き

身体的特性，転倒に関連する主な身体機能，最大ステップ長（MSL）及び急ぎステップ課題中の所要時間と床反力作用点（COP: center of pressure）の総軌跡長を 2 日間に分けて計測した。第 1 日目は身体的特性と身体機能（膝伸展力，閉眼片足立ち，ファンクショナルリーチテスト），第 2 日目には，MSL と急ぎステップ課題の計測を実施した。いずれにおいても参加者には各々が履き慣れた運動用の靴を履いてもらった。

Tab.1 若年者と高年齢者の身体的特性，身体機能，最大一歩幅（MSL）

	若年者 (n=10)	高年齢者 (n=28)
年齢 [歳]	23 ± 3	65 ± 2*
身長 [cm]	174 ± 5	165 ± 6*
体重 [kg]	67 ± 6	65 ± 8
下肢長 [cm]	89 ± 5	84 ± 5*
膝伸展力 [kg]	102 ± 23	65 ± 13*
閉眼片足立ち [秒]	115 ± 93	16 ± 16*
ファンクショナルリーチ [cm]	44 ± 6	31 ± 6*
MSL [cm]		
右脚前	127 ± 8	103 ± 9*
左脚前	129 ± 9	105 ± 10*
右脚右横	113 ± 7	99 ± 8*
左脚左横	115 ± 9	101 ± 9*
右脚後	130 ± 9	111 ± 11*
左脚後	130 ± 8	109 ± 12*

値は平均値±標準偏差。*若年者と比較して有意に異なる（$p < .05$）。

2・3. 実施課題

転倒に関連する主な身体機能として，下肢筋力（膝伸展力），静的バランス機能（閉眼片足立ち），動的バランス機能（ファンクショナルリーチテスト）を測定した。

- 膝伸展力：脚筋力測定台（T.K.K.5710m，竹井機器工業）を用い，椅座位で両足の膝関節および足関節を 90 度屈曲した姿勢から膝を伸展させたときの最大等尺性筋力を 2 回測定し最大値を記録した。
- 閉眼片足立ち：両眼を閉じてから任意の片足を挙上し，挙上した足が反対側の足に接触しないで，かつ両手が身体に接触しないでその姿勢を維持できる時間を 2 回測定し最大値を記録した。
- ファンクショナルリーチテスト：両足を肩幅程度に開いて直立した足の位置を所定位置とし，両手指先をできるだけ前方に伸ばして両上肢を肩関節屈曲 90 度まで挙上し，足の位置を動かすことなく身体をできる限り前傾させ，その後，足の位置を動かすことなく直立姿勢に戻ることが可能な両手指先の水平方向移動距離を 3 回測定し最大値を記録した。

MSL は，胸の前に両上肢を交差したまま，ある方向（前，後，左，または右）に片足で 1 歩踏み出し，その後，踏み出した足を最初の位置まで 1 歩で戻すことが可能な最大ステップ長とした。Medell らの方法(4)に準じて，左右脚の各方向（右脚前，右脚右横，右脚後，左脚前，左脚左横，左脚後）について 5 回ずつ測定し平均値を記録した。

急ぎステップ課題では，参加者は前方に位置するディスプレイ上に提示された指示［踏み出す足（左，右）と方向（前，左，右，後）がわかる絵］に従ってステップ動作を繰り返した。参加者は，画面の指示に従い，事前に計測した MSL に基づいて決定されたステップ位置［最大ステップ長の 80%（80%MSL）ないしは 70%（70%MSL），60%（60%MSL）］に貼られた目標テープを踏むないしは越えるようにステッピング動作を繰り返した（Fig.1）。ディスプレイ上には，踏み出し

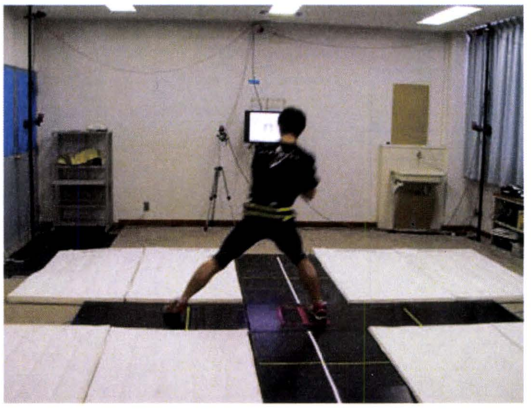

Fig. 1 急ぎステップ課題の実施風景
前方のディスプレイの指示に従い左足を横にステッピングしている。

た足が元の位置［赤色のテープで囲まれた両足が入る所定のボックス内（35.6×30.5cm）］に戻ったと同時に次の指示が 1 秒間提示され，その後に初期画面（両足がボックス内でそろった絵）が表示されるようにした。参加者は，できるだけ素早くかつ指示通りにステッピングするように教示された。1 試行当たりのステッピング回数は 37 回で，ステップの順序はランダムであった。ただし連続する 2 つのステップの順序は重複がないようにした。

急ぎステップ課題中は，ステップ時の支持脚および両足がボックス内に戻ったときの足圧中心動揺を 2 台の可搬型床反力計（9286, Kistler）を用い，サンプリング周波数 1,000Hz にてパソコンに記録した。急ぎステップ課題は各ステップ長につき 2 試行ずつ実施し，開始から終了までの所要時間と COP 総軌跡長それぞれの平均値を記録した。

２・４．統計解析

若年者と高年齢者，あるいは高年齢転倒非経験者と高年齢転倒経験者の間の比較には二元配置分散分析，あるいは対応のない t 検定を用いた。また多重比較には Bonferroni 法を用いた。MSL，急ぎステップ課題の所要時間，COP 総軌跡長，基礎体力との間の関係は，Pearson の積率相関または年齢を調整した偏相関係数を求めた。なお有意水準は 5%未満とした。

３．結 果

３・１．年齢による比較

Tab.1 に年齢群別の身体的特性及び身体機能の測定値を示す。若年者の膝伸展力，ファンクショナルリーチテスト，閉眼片足立ちの成績は高年齢者と比較して有意に高かった（$p<.05$）。若年者の MSL は全ての目標位置において高年齢者よりも有意に長かった（$p<.05$）。

急ぎステップ課題の所要時間を Tab.2 に示す。年齢群（若年者，高年齢者）×ステップ幅（80%MSL，70%MSL，60%MSL）の二元配置分散分析の結果，年齢群及びステップ幅の主効果が認められた（$p<.05$）。若年者の急ぎステップ課題の所要時間は高年齢者に比べて有意に短かった（$p<.05$）。またステップ幅については，70%MSL での所要時間は 80%MSL に比べて有意に短かった（$p<.05$）。また 60%MSL での所要時間は，70%MSL 及び 80%MSL に比べて有意に短かった（$p<.05$）。なお，年齢群×ステップ幅の交互作用は認められなかった（$p>.05$）。

Tab.2 急ぎステップ課題の所要時間［秒］

	若年者 (n=10)	高年齢者 (n=28)
80% MSL	83.2 ± 7.1	100.1 ± 11.8*
70% MSL	74.9 ± 5.8a	92.7 ± 10.6*a
60% MSL	71.4 ± 5.8b	88.6 ± 10.8*b

値は平均値±標準偏差。*若年者との比較（$p<.05$）。[a]80%MSL との比較（$p<.05$）。[b]他のステップ幅との比較（$p<.05$）。

次に，急ぎステップ動作中の COP 総軌跡長を Fig. 2 に示す。年齢群×ステップ幅の二元配置分散分析の結果，年齢群の主効果のみが有意であり，いずれのステップ幅でも高年齢者の COP 総軌跡長は若年者に比べて有意に長かった（$p<.05$）。

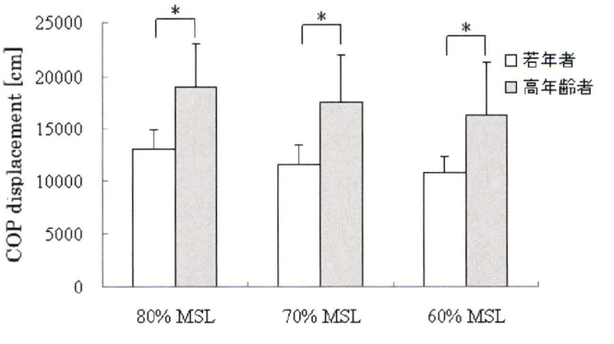

Fig. 2 若年者と高年齢者の急ぎステップ課題時の床反力作用点（COP）総軌跡長
値は平均値±標準偏差。*$p<.05$。

急ぎステップ課題の所要時間あるいは COP 総軌跡長と膝伸展力，ファンクショナルリーチテスト，閉眼片足立ちおよび MSL との相関分析の結果をそれぞれ Tab.3 と Tab.4 に示した。急ぎステップ課題の所要時間と膝伸展力，ファンクショナルリーチテスト，閉眼片足立ちの間には若年者，高年齢者ともに有意な相関は認められなかった（$p>.05$）。一方，急ぎステップ課題の所要時間は，若年者の場合，70%MSL 時では右脚後と左脚後の MSL と，60%MSL 時では左脚後の MSL と

Tab. 3 急ぎステップ課題の所要時間と身体機能等の相関係数

	若年者 (n=10)			高年齢者 (n=28)		
	80% MSL	70% MSL	60% MSL	80% MSL	70% MSL	60% MSL
膝伸展力	-.152	-.060	-.130	.077	.097	.000
閉眼片足立ち	-.096	-.076	-.119	.234	.087	.165
ファンクショナルリーチ	.061	-.106	.026	-.148	-.164	-.170
MSL						
右脚前	-.285	-.242	-.125	.119	.044	.129
左脚前	-.105	-.092	.025	.268	.191	.281
右脚右横	-.425	-.443	-.275	.289	.241	.282
左脚左横	-.260	-.376	-.184	.253	.150	.208
右脚後	-.592	-.654*	-.629	.391*	.244	.284
左脚後	-.605	-.649*	-.661*	.338	.229	.248

*$p<.05$

Tab. 4　急ぎステップ課題時の床反力作用点（COP）総軌跡長と身体機能等の相関係数

	若年者 (n=10)			高年齢者 (n=28)		
	80% MSL	70% MSL	60% MSL	80% MSL	70% MSL	60% MSL
膝伸展力	-.466	-.515	-.421	-.054	-.019	-.073
閉眼片足立ち	-.567	-.181	-.326	.072	.009	.041
ファンクショナルリーチ	-.183	-.578	-.561	-.039	-.084	-.025
MSL						
右脚前	-.415	-.334	-.251	.036	.060	.075
左脚前	-.289	-.323	-.207	.146	.195	.149
右脚右横	-.007	-.053	.060	-.306	-.211	-.204
左脚左横	.128	.045	.100	-.207	-.166	-.152
右脚後	-.169	-.213	-.279	-.156	-.185	-.188
左脚後	-.061	-.154	-.229	-.136	-.139	-.151

有意な相関が認められた（$p < .05$）。高年齢者では 80%MSL 時で右脚後の MSL と有意な相関が認められた（$p < .05$）。COP 総軌跡長では，若年者，高年齢者ともに有意な相関が認められなかった（$p > .05$）。

3・2．転倒経験の有無による比較

高年齢者を転倒経験の有無で群分けし，身体機能，MSL，急ぎステップ課題を比較した。転倒経験は，過去 1 年間の日常生活時の転倒回数を自己申告により調べた。転倒は Gibson の定義[5]に従い「本人の意思からではなく，地面またはより低い面に身体が倒れること」とした。過去 1 年間に転倒経験のなかった高年齢者は 22 名，過去 1 年間に転倒した経験があった男性は 6 名で，それぞれ高年齢転倒非経験者，高年齢転倒経験者とした。各群の身体的特性及び身体機能を Tab. 5 に示した。

膝伸展力，ファンクショナルリーチテスト，閉眼片足立ちには，転倒経験の有無による有意な差は認められなかった（$p > .05$）。また，MSL にも両群間に有意な差は認められなかった（$p > .05$）（Tab.5）。

Tab.5　転倒経験の有無と身体的特性，身体機能，MSL

	高年齢転倒非経験者 (n=22)	高年齢転倒経験者 (n=6)
年齢 [歳]	64 ± 2	66 ± 3
身長 [cm]	165 ± 6	163 ± 6
体重 [kg]	65 ± 8	64 ± 4
下肢長 [cm]	84 ± 5	84 ± 5
膝伸展力 [kg]	67 ± 12	57 ± 12
閉眼片足立ち [秒]	17 ± 17	11 ± 10
ファンクショナルリーチ [cm]	31 ± 7	34 ± 3
転倒経験［回数］	—	2 (1 - 5)
MSL [cm]		
右脚前	104 ± 8	102 ± 13
左脚前	106 ± 9	100 ± 12
右脚右横	100 ± 7	95 ± 9
左脚左横	102 ± 8	97 ± 10
右脚後	112 ± 12	108 ± 8
左脚後	110 ± 13	106 ± 8

値は平均値±標準偏差。転倒経験のみ平均値（範囲）。

急ぎステップ課題の所要時間について，転倒経験（転倒経験あり，なし）×ステップ幅（80%MSL，70%MSL，60%MSL）の二元配置分散分析を行った結果，ステップ幅の主効果が認められたが（$p < .05$），転倒経験の主効果と転倒経験×ステップ幅の交互作用は有意ではなかった（$p > .05$）（Tab.6）。COP 総軌跡長については有意な主効果，交互作用は認められなかった（$p > .05$）（Fig.3）。

Tab.6　高年齢転倒非経験者と高年齢転倒経験者の急ぎステップ課題の所要時間 [秒]

	高年齢転倒非経験者 (n=22)	高年齢転倒経験者 (n=6)
80% MSL	101.7 ± 11.6	94.0 ± 10.6
70% MSL	93.9 ± 10.2a	88.2 ± 11.5a
60% MSL	89.8 ± 10.4b	84.0 ± 11.3b

値は平均値±標準偏差。[a]80%MSL との比較（$p < .05$）。[b]他のステップ幅との比較（$p < .05$）。

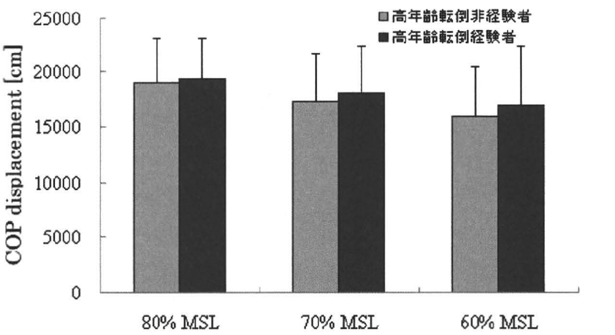

Fig. 3　高年齢転倒非経験者と高年齢転倒経験者の急ぎステップ課題時の COP 総軌跡長
値は平均値±標準偏差。

4．考 察

4・1．身体機能：年齢差，転倒経験との関連

高齢者の転倒の要因としてあげられている下肢筋力（膝伸展力），静的バランス機能（閉眼方足立ち），動的バランス機能（ファンクショナルリーチテスト）では，若年者の成績が高年齢者より高く，加齢による影響が認められた。一方，高年齢転倒非経験者と高年齢転倒経験者との間では有意な差は認められなかった（$p > .05$）。本研究の転倒経験者は，本研究で調べた身体機能の低下以外の要因によって転倒をした可能性があると考えられた。

4・2．MSL 及び急ぎステップ課題：年齢差，転倒経験，身体機能との関連

MSL はすべての目標位置において若年者より高年齢者の方が短かった（$p < .05$）。この結果は女性のみを対象にした Medell らの結果[4]とも一致することから，MSL は性別によらず加齢にともない短くなると考えられた。

急ぎステップ課題の所要時間及び COP 総軌跡長も，全てのステップ幅で若年者と高年齢者の間で差が認められた（$p < .05$）。両者の関連性を年齢の影響を取り除いた偏相関係数を用いて検討したところ，全てのステップ幅で有意な関係は認められなかった（$p > .05$）。つまり，全てのステップ幅について，課題動作時の COP 総軌跡長は所要時間の長さに関係するものではなく，動作中のふらつきの程度を反映していると考

えられた。

高年齢転倒者と非転倒者との間では急ぎステップ課題の所要時間，COP 総軌跡長にはいずれのステップ幅についても差がなかった（$p > .05$）。したがって，MSL の 80%，70%，60% のステップ幅に設定した急ぎステップ課題を用いて高年齢者の転倒リスクを評価することが困難であると考えられた。さらに，急ぎステップ課題の所要時間あるいは COP 総軌跡長と各身体機能の測定値には有意な相関は認められなかった（$p > .05$）。以上より，急ぎステップ課題の成績が転倒リスクを評価できるかについては，今後慎重に検討する必要があるであろう。

高年齢者について MSL と膝伸展力との間には，後方向を除き有意な関連性（右脚前：r=.469，右脚右横：r=.522，左脚前：.r=421，左脚左横：r=.516）が認められた（$p < .05$）。ステッピング動作では主に足と膝関節を大きく屈曲・伸展させる筋力が要求されるが，後方向については慣れない動作であるため，参加者は下肢筋力のパフォーマンスを最大に発揮することができなかったことが影響したと考えられた。したがって，前あるいは横方向の MSL は高年齢者の下肢筋力を反映する指標，あるいは下肢筋力に関連する転倒のリスク評価指標となりうる可能性があると考えられた。

5．結 論

本研究では，最大一歩幅（MSL）及び急ぎステップ課題と，年齢，筋力，バランス機能，高年齢者の転倒経験の有無との関係を検討した。その結果，下肢筋力（膝伸展力），静的バランス機能（閉眼片足立ち），動的バランス機能（ファンクショナルリーチテスト），MSL，急ぎステップ課題の成績（所要時間，COP 総軌跡長）に加齢による影響が認められた。一方，高年齢転倒非経験者と高年齢転倒経験者との間では身体機能，MSL，MSL の 80%，70%，60%のステップ幅での急ぎステップ課題の成績に差は認められなかった。ただし，高年齢者で，前と横方向の MSL は膝伸展力と有意な正の関係が認められた。

以上より，急ぎステップ課題を用いて高年齢者の転倒リスクを評価することは困難と考えられた。一方，前あるいは横方向の MSL は高年齢者の筋力を反映する指標，あるいは下肢筋力に関連する転倒のリスク評価指標となりうる可能性があると考えられた。

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