

# Comparison of Physical Function by Age and MADS Complex Diagnosis in Community-dwelling Elderly Women

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**Abstract.** [Purpose] The purpose of the present study was to compare the physical function of early- and latter-stage elderly with and without the musculoskeletal ambulation disability symptom (MADS) complex, and examine their characteristics. [Subjects] Subjects were 211 elderly females living in the community. [Methods] Comparisons of the physical function were conducted between those with and without the MADS complex and two age groups. [Results] A markedly larger number of latter-stage elderly had the MADS complex than those in the early stage. The walking ability was significantly lower in the MADS complex and latter-stage elderly groups. Although the score for muscle strength was markedly lower in the latter-stage elderly group, no significant difference was noted between those with and without the MADS complex. There was no marked difference in the score for the sit-and-reach flexibility between the MADS and non-MADS and two age groups. [Conclusion] A markedly larger number of MADS complex patients were in the latter- than in the early-stage elderly group, and the physical function of the latter-stage elderly was lower. The walking ability of the elderly with the MADS complex was very low.

**Key words:** Musculoskeletal ambulation disability symptom complex, Elderly females living in the community, Physical function

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## INTRODUCTION

In Japan, which has the world's highest longevity rate<sup>1)</sup>, the elderly aged 65 or older accounted for around 23% of the total population<sup>2)</sup> and the average life expectancy for females was 86.1 in 2010. The number of elderly females was 16.59 million, which accounted for 25.4% of the female population; in other words, one in four Japanese females is elderly. Particularly, the population of the latter-stage elderly aged 75 or older has rapidly increased, and it constituted around 11% of the total population as of 2010<sup>1)</sup>. Benefits for elderly people comprise approximately 69% of the total social security benefit expenditure owing to the increase in the number of the latter-stage elderly and the gap between average and healthy life expectancy<sup>3)</sup>. There has also been a sharp increase in the number of elderly who receive public nursing care services<sup>4)</sup>. In this context, increasing the healthy as well as average life expectancy has become a social challenge, and measures are being adopted to help the elderly live a healthy and independent life, with more emphasis placed on care prevention. Under these circumstances, one of the important tasks is maintenance of the locomotory

function because its dysfunction is closely associated with a variety of long-term care needs<sup>5)</sup>. To support the independent life of the elderly, it is necessary to help them to prevent locomotive or musculoskeletal disorders at an early stage and maintain their ability to move<sup>5)</sup>.

In Japan, with the aim of preventing musculoskeletal disorder, the "musculoskeletal ambulation disability symptom (MADS) complex" was defined<sup>6)</sup>. According to the definition, the MADS complex refers to a state caused by a decline in the abilities to maintain balance and move due to aging, which poses high risks of withdrawal from society and falling. It has been suggested that early detection of the MADS complex and interventions such as rehabilitation to maintain the musculoskeletal function effectively increases the healthy life expectancy<sup>6)</sup>. Although evaluation of the physical function is used as a criteria for diagnosis of the MADS complex<sup>6)</sup>, it is implemented in a uniformed manner without taking into account differences in age and gender. There are reports of decreases in the walking ability including the stride length<sup>7)</sup>, balance ability in a standing position (due to a forward-bending posture while walking)<sup>8)</sup>, and muscle strength in the leg in the latter-stage elderly<sup>9)</sup>.

**Table 1 .** Diagnostic criteria for locomotor instability

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Those who have (or have a history of) any of the following eleven disorders associated with a decrease in physical capabilities, and whose level of self-reliance in daily life or physical capabilities is “1” or “2” as defined in the “criteria for the assessment of functions” below.

[Disorders associated with a decrease in physical capabilities]

- Vertebral compression fracture and spinal deformities
- Lower-limb fracture
- Osteoporosis
- Osteoarthritis
- Lumbar spinal canal stenosis
- Spinal disorders
- Neurological and muscular disorders
- Rheumatoid arthritis and other arthritic diseases
- Lower-limb amputation
- Locomotor dysfunction following a prolonged bedridden state
- Frequent falls

[Criteria for the assessment of functions]

1. Level of self-reliance in daily life: Rank J and A (In Need of Support + In Need of Care State I or II)
2. Physical capabilities: 1) or 2)
  - 1) Time of being able to stand on one foot with the eyes open: less than 15 seconds
  - 2) Three-meter timed up and go test: 11 seconds or longer

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Created based on the diagnostic criteria for locomotor instability (Hiromoto Ito)<sup>6)</sup>.

However, there has been no study conducted which has examined the effects of the MADS complex and aging on their physical function of the elderly. MADS is a recently defined condition involving diverse pathological conditions; therefore, there are few studies which have examined the characteristics of physical function common to all its primary causes.

The present study was conducted to compare the physical function of early- and latter-stage elderly with and without the musculoskeletal ambulation disability symptom (MADS) complex to examine the physical characteristics of elderly females living in the community.

## METHODS

### 1. Subjects

The subjects were 221 elderly females aged 65 to 85 years old who were living an independent life in Town A. Their mean age, height, and weight were  $74.4 \pm 5.4$ ,  $147.5 \pm 6.5$  cm, and  $51.1 \pm 8.7$  kg, respectively. There were 114 early- and 107 latter-stage elderly. In the early-stage elderly group, 18 people had the MADS complex and 96 did not, and, in the latter-stage group, 49 had the disorder and 58 did not. All subjects were provided with an explanation of the study objectives and details, as well as ethical considerations. They were also given including a guarantee of privacy protection and completely voluntary participation and withdrawal, in order to obtain their consent. This study was conducted with the approval of the Research Ethics Committee of Nishi Kyushu University.

### 2. Methods

After collecting subject attribute data, motor function assessments (standing on one leg with eyes open and TUG) were conducted. We classified the subjects with and without potential MADS, which was determined by using the evaluation criteria for the disease (Table1). To evaluate the physical function, the following tests were conducted to measure the walking ability, muscle strength, and flexibility: one-leg standing time, timed up-and-go-test, walking speed; 10-m obstacle walking time; 6-minute walking distance; hand grip strength; quadriceps muscle strength; sit-and-reach flexibility.

The ability to stand on one leg with eyes open was measured as directed by the New Physical Fitness Test for the Elderly published by the Ministry of Education, Culture, Sports, Science, and Technology<sup>10)</sup>. A digital stopwatch was used for timing, and the maximum time was set as 120 seconds. The time was recorded twice for each leg, and the longest time was adopted. Subjects were instructed to stand without their shoes, place their arms at their sides, and look 2 m forward at the height of their eyes.

TUG was conducted using the method of Podsiadlo and colleagues<sup>11)</sup>. The time needed to stand up from a chair, walk toward a target at a distance of 3 m, reverse direction, and return to sit on the chair again was measured using a digital stopwatch.

To measure the walking speed, subjects were instructed to walk a flat 11-m course at their maximum speed. Measurement of the time taken to walk the middle 5 m was performed twice using a digital stopwatch, and the fastest speed was adopted<sup>12)</sup>.

Measurement of the 10-m obstacle walking time also

**Table 2.** The mean of measurements of exercises and standard deviation of test measurements in the MADS and non-MADS and early- and latter-stage elderly groups

	Early stage N=114	Latter stage N=107	With potential MADS N=67	Without potential MADS N=154
Height (cm)	149.9 ± 6.2	145.1 ± 5.8	146.8 ± 6.8	147.9 ± 6.3
Weight (kg)	52.7 ± 8.9	49.4 ± 8.1	52.4 ± 9.6	50.5 ± 8.2
Walking speed (m/sec)	1.9 ± 0.4	1.6 ± 0.4**	1.5 ± 0.4	1.9 ± 0.5##
10-m obstacle walking time (sec)	7.3 ± 3.5	9.3 ± 3.7*	9.6 ± 4.1	7.6 ± 3.4##
6-minute walking distance (m)	461.8 ± 87.8	356.8 ± 132.5**	332.9 ± 132.4	444.1 ± 103.0##
Grip strength (%)	44.2 ± 9.1	41.2 ± 8.6	38.5 ± 8.1	44.6 ± 8.7##
Quadriceps muscle strength (%)	37.9 ± 9.7	33.4 ± 8.7	32.5 ± 8.2	37.2 ± 9.7##
Sit-and-reach flexibility (cm)	39.9 ± 8.6	38.1 ± 7.4	38.9 ± 7.9	39.1 ± 8.2

Data are expressed as means ± SD. MADS: musculoskeletal ambulation disability symptom complex. \* $p < 0.05$ , \*\* $p < 0.01$ : significantly higher in the early-stage elderly groups. ## $p < 0.01$ : significantly higher in the without potential-MADS groups. A two-way interaction was noted for the grip strength between the MADS complex and age

followed the New Physical Fitness Test for the Elderly published by the Ministry of Education, Culture, Sports, Science, and Technology<sup>10</sup>). The time needed to walk a straight 10-m course at the maximum speed while avoiding six 20 cm-high sponge obstacles placed at intervals of 2 m was measured. Measurement was performed twice using a digital stopwatch, and the shortest time was adopted.

For the 6-minute walking distance, subjects walked around a 30-m indoor circuit as many times as possible for 6 minutes. The distance walked was recorded in meters<sup>13</sup>).

The hand grip strength was measured using a digital dynamometer (Takei Scientific Instruments Co., Ltd.). Subjects were instructed to stand with their arms straight at their sides. Measurement was performed twice on each side, and the greatest value was adopted.

The quadriceps muscle strength was measured using a hand-held dynamometer (an isometric muscle strength measurement device by ANIMA Corp.) in the sitting position with the knee angle at 90 degrees. Measurement was performed twice on each side, and the greatest value was adopted.

The sit-and-reach flexibility test also followed the New Physical Fitness Test for the Elderly published by the Ministry of Education, Culture, Sports, Science, and Technology<sup>10</sup>). Subjects were instructed to sit on the floor with their legs equally stretched out in front of them, their knees straight, and their ankle joints at 90 degrees. Measurement was performed twice using a digital sit-and-reach flexibility measurement device (Takei Scientific Instruments Co., Ltd.), and the longest distance was adopted.

For statistical processing, the subjects were categorized into two groups: MADS and non-MADS groups, according to the criteria for the evaluation of the MADS complex. Two-way analyses of variance were conducted with measurements of the walking speed, walking time over the 10-m obstacle course, distance walked in six minutes, grip strength, quadriceps strength, and sit-and-reach flexibility as dependent variables and the MADS complex (MADS and non-MADS groups) and age (early- and latter-stage elderly groups) as independent variables. When an interaction

was noted between two factors for an item, a comparison was performed to examine the simple main effects. The chi-square tests was conducted to determine whether the ratio of those with the MADS complex and the number of elderly in each of the two groups were appropriate. SPSS17.0 J for Windows was used for these analyses, with a significance level of 5%.

## RESULTS

A markedly larger number of latter-stage elderly had the MADS complex than those in the early stage (chi-square value=23.5,  $p < 0.01$ ). Table 2 shows the mean of measurements of exercises and standard deviation of the test measurements according to group: The scores for the walking speed, walking over the 10-m obstacle course, and the distance walked in six minutes were significantly higher in the non-MADS and early-stage elderly groups, and marked main effects were noted. A two-way interaction was noted for the grip strength between the MADS complex and age, and the result of the test for simple main effects showed that the MADS complex affected the grip strength ( $F=9.9$ ,  $p < 0.01$ ). Regarding the grip strength, there were marked differences between the age groups in both the MADS ( $F=16.3$ ,  $p < 0.05$ ) and non-MADS ( $F=5.5$ ,  $p < 0.01$ ) groups. A main effect was noted for the quadriceps strength between the age groups. However, no significant main effect was noted for the sit-and-reach flexibility between the MADS and non-MADS or the two age groups (Table 2).

## DISCUSSION

In this study of elderly females living in the community, a significantly larger number of latter-stage elderly had the MADS complex than those in the early-stage group. Comparisons of physical function between the MADS and non-MADS and two age groups showed that abilities to perform all types of exercise that are indices of the walking ability were markedly lower in the MADS complex and latter-stage elderly groups. There was no significant difference in

exercises serving as indices of the muscle strength between the MADS and non-MADS groups, although the scores were tended to be lower in the latter-stage elderly group. Regarding the sit-and-reach flexibility, no marked difference was noted between the MADS and non-MADS or the two age groups.

The result that a decrease in the walking ability was noted in a larger number of latter-stage elderly is agreement with those of previous studies<sup>7, 8</sup>. Berg et al.<sup>14</sup> reported that the walking speed is closely related to balance ability. There is also a report that the walking speed is representative of a person's exercise capacity<sup>15</sup>. According to Brown et al.<sup>16</sup>, the ability to walk over an obstacle course is associated with the risk of falling. The distance that can be walked in six minutes is reported to be closely related to activities of daily living<sup>17</sup>. The MADS complex is defined as a state caused by a decline in the abilities to maintain balance and movement, which poses high risks of withdrawal from society and falling<sup>6</sup>. Significant differences were noted in all walking-related abilities between both MADS and non-MADS and the two age groups, which clearly suggests that a decrease in the walking ability is a prominent symptom of the MADS complex.

Grip and quadriceps strengths, which are indices of the muscle strength, were markedly lower in the latter-stage elderly group. Previous studies have presented similar results, reporting that, as the age increases, the muscle strength declines more in the legs than in the arms<sup>18</sup>. There was no significant difference in the quadriceps strength between the MADS and non-MADS groups. Sakada et al.<sup>19</sup>, using the one-leg standing time of being able to stand on one leg with the eyes open as a criterion for evaluation of the MADS complex, established two categories: the less than and 15 seconds or longer groups, and reported a marked decline in the muscle strength in the former group. The population of the present study differed from those of the previous studies because all subjects were female and there was a relatively small number of MADS complex patients in the early-stage elderly group. The effects of differences in age and gender should be carefully examined to determine whether a decrease in the muscle strength is able the MADS complex.

There was no marked difference in the score of the sit-and-reach flexibility, an index of flexibility, between the latter- and early-stage elderly groups, which is agreement with the result of a previous study that also reported no significant difference in the sit-and-reach flexibility between age groups<sup>20</sup>. No marked difference was not noted between the MADS and non-MADS groups either. The result is consistent with that of another previous study which reported that sit-and-reach flexibility requires a different type of capability and is not significantly associated with abilities to perform walking ability and most other exercises<sup>15</sup>.

Taken together these findings suggest that the physical function of the latter-stage elderly is markedly lower than that of the early-stage elderly. Particularly, the walking ability of the elderly with the MADS complex was very low. As the walking ability is often decreased in the latter-stage elderly, even if they do not have the MADS complex, care,

prevention and rehabilitation to improve the musculoskeletal function should be implemented for them. However, the results of the present study might not apply to the fragile elderly as the subjects of this study were all able to live an independent daily life. The diagnosis of MADS was not made by physicians, and, therefore, the diagnosis may not necessarily be correct. This is a limitation of this study, and it will be necessary to confirm whether subjects with potential MADS actually have the disease at medical facilities.

Further studies involving the elderly with a wider range of physical function should be conducted. The effects of differences between a larger number of age groups and in gender should also be considered when examining the clinical aspects of the MADS complex in detail.

## REFERENCES

- 1) United Nation: <http://www.un.org/en/development/proareas/population.shtml> (Accessed Nov. 12, 2011).
- 2) Statistics Bureau: <http://www.stat.go.jp/data/topics/topi411.htm> (Accessed Nov. 30, 2011).
- 3) National Institute of Population and Social Security Research: [http://www.ipss.go.jp/ss-cost/j/kyuhuhi-h21/kyuuhu\\_h21.asp](http://www.ipss.go.jp/ss-cost/j/kyuhuhi-h21/kyuuhu_h21.asp) (Accessed Nov. 30, 2011).
- 4) Ministry of Health, Labour and Welfare: <http://www.mhlw.go.jp/toukei/saikin/hw/kaigo/kyufu/2011/01hyo02.html> (Accessed Nov. 30, 2011).
- 5) Guralnik JM, Ferrucci L, Simonsick EM, et al.: Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med*, 1995, 332: 556–561. [Medline] [CrossRef]
- 6) Ito H: Diagnosis of musculoskeletal ambulation disability symptom complex (MADS). *Clin Calcium*, 2008, 18: 1560–1565 (In Japanese). [Medline]
- 7) Elble RJ, Thomas SS, Higgins S, et al.: Stride-dependent changes in gait of older people. *J Neurol*, 1991, 238: 1–5. [Medline] [CrossRef]
- 8) Elble RJ, Masdeu JC, Alampur U, et al.: Change in gait with normal aging. Philadelphia: Lippincott-Raven, 1997, pp 93–105.
- 9) Nishijima T, Takahashi S, Ohishi T, et al.: The sensitivity of Japan fitness test in elderly people to assess the effects of aging. *International of Sport and Health Sci*, 2006, 4: 583–590.
- 10) Ministry of Education Culture Sports Science and Technology: [http://www.mext.go.jp/a\\_menu/sports/stamina/03040901.htm](http://www.mext.go.jp/a_menu/sports/stamina/03040901.htm) (Accessed Nov. 30, 2011) (In Japanese).
- 11) Richardson PD: The Time "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc*, 1991, 39: 142–148. [Medline]
- 12) Bohannon RW: Comfortable and maximum walking speed of adults aged 20–79 years: reference values and determinants. *Age Ageing*, 1997, 26: 15–19. [Medline] [CrossRef]
- 13) ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories: Statement AT: Guidelines for the Six-Minute Walking Test. *Am J Respir Crit Care Med*, 2002, 166: 111–117. [Medline]
- 14) Berg K, Wood DS, Williams JI, et al.: Measuring balance in the elderly: preliminary development of an instrument. *Physiother Can*, 1989, 41: 304–311. [CrossRef]
- 15) Nagasaki H, Itoh H, Furuta T: A physical fitness model of older adults. *Aging*, 1995, 7: 392–397. [Medline]
- 16) Brown LA, McKenzie NC, Doan JB: Age-dependent differences in the attentional demands of obstacle negotiation. *J Gerontol A Biol Sci Med Sci*, 2005, 60: 924–927. [Medline]
- 17) Enright PL, Mcburnie MA, Bittner V, et al.: The 6-min walk test: a quick measure of functional status in elderly adults. *Chest*, 2003, 123: 387–398. [Medline] [CrossRef]
- 18) Janssen I, Heymsfield SB, Wang ZM, et al.: Skeletal muscle mass and distribution in 468 men and women aged 18–88yr. *J Appl Physiol*, 2000, 89: 81–88.
- 19) Sakada T, Doi M, Hosokawa T, et al.: The relationship between the physical strength in elderly local residents and unstable locomotrium disease. *The Journal of Saitama Kenou Rehabilitation*, 2007, 7: 15–19 (In Japanese).
- 20) Kimura M, Morimoto Y, Terada M: Exercise habits and physical performance in aged city dweller. *Jpn Soc Phys Fit Sports Med*, 1991, 40: 475–479 (In Japanese).