Physical Factors Affecting Daily Walking Activities among Elderly Female Residents of a Care House

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Abstract

To understand the physical and other factors related to walking among the elderly residents of a Care House for the aged, the total number of steps walked were measured over a period of 1 week (Nov. 6-12, 1994) for 67 female residents (mean age 79 ± 1 years). In addition, walking speed, stride length, and the time to climb 15 steps (stair-climbing time) were measured. To understand the indirect factors such as balance and agility that may control walking, tests were conducted on the subjects' ability to stand on one leg with eyes open and closed, and jumping reaction time. Results showed a negative correlation between total number of steps and age ($r=-0.543$, $P<0.01$), jumping reaction time ($r=-0.258$, $p<0.05$) and stair-climbing time ($r=-0.501$, $P<0.01$).

However, a positive correlation was found between total number of steps and stride length ($r=0.408$, $P<0.01$), walking speed ($r=0.419$, $P<0.01$), self-rated health ($r=0.390$, $P<0.05$) and standing on one leg with eyes closed ($r=0.258$, $P<0.05$). The total number of steps walked and physical factors, particularly physique and balance, were also closely related. The above suggests that a walking habit among elderly persons helps to slow the decline in physical strength, which is necessary to prevent falls. It is also reflected in the person's awareness of health and may increase the opportunities for leading an active daily life.

Key words: care house, aged people, walking activity, ability to stand on one leg with eyes closed, self-rated health

Introduction

Japan is an aging society. The decline in physical ability with age results in decreased physical activity in daily life, which is in turn accompanied by atrophy of the muscles from disuse and presents the possibility of an increase in the number of bedridden elderly¹⁾. On the other hand, Jette et al²⁾ have indicated that appropriate exercise can prevent the decline in strength that comes with age. Above all, it is known that regular walking contributes to various physical factors, including balance and leg strength which are both important in physical activities in daily life³⁻⁵⁾. Moreover, it has been reported that a walking habit strongly affects a person's awareness and evaluation of his or her own health⁶⁾. This suggests the possibility that regular walking can be an indicator of the degree of prevention in the decline in strength in daily activities. However, no research has clearly

indicated that the number of steps walked by elderly persons can be an indicator of both of the other aspects of physical strength and evaluation of one's own health.

However, if the appropriateness of the type and intensity of physical activity for the elderly is not considered, it may have the opposite effect of causing various injuries. The desired type of activity would be one that is directly connected to the person's daily life, and for this an objective understanding is important. To gain such an understanding, it is necessary when working with elderly subjects living at home to perform rigorous measurements in such a way that conforms to the subjects' daily life. One strategy for this would be to place subjects in the same living environment for a long period, but due to the age of the subjects consideration of safety makes this difficult. There are other possibilities, however. A system of nursing homes called Care Houses was established in Japan in 1988 for the purpose of prolonging independence among the elderly by providing a supportive environment. In these Care Houses, all residents live for long periods in the same surroundings and follow the same daily routine (meals, sleeping and waking times). These homes are thus superbly suited to gaining an objective understanding of changes that take place in the elderly over time.

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The present study, with the elderly of one such Care House as subjects, we measured the total number of steps walked and physical factors thought to be related to this, as well as conducted a self-rated health survey with the aim of clarifying the relationships among these. We investigated whether it is possible to use the amount of walking, as measured by number of steps, by elderly people as an indicator of other physical factors as well as subjective feelings of health.

Material and methods

Subjects

The subjects were 67 of 69 female residents of a Care House (2 were excluded due to lack of ability to leave the facility), opened in 1994 in Hyogo Prefecture, who consented to undergoing measurements of the number of steps walked and tests of physical strength. The mean age of the subjects was 79 ± 1 (mean $\pm$ SE) years. None of the subjects had any impairments in walking or in daily activities. In a survey of ADL (activities of daily living)⁷⁾, all subjects were judged by an investigator to have mean scores of 2 or above (on a 3-step evaluation) on the items of "daily chores," "movement," "living habits," "order in personal affairs," "meals," and "personal relations."

Measurements

Measurements of height (cm), weight (kg) and body mass index (BMI; weight/height², kg/m²) were taken as Physical factors.

The number of steps walked was measured using a pedometer (Calorie Counter Select-2, Suzuken, Co.)⁸⁾ at 3 times (9:00, 13:00, 17:00) in approximately 12 hours from the time the subjects rose in the morning until after their evening meal, during the week of November 6-11 (1994). These totals were taken as the daily number of steps (after 17:00 and the evening meal, residents spent the remainder of the evening in their rooms unless there was a special event), and used to calculate a one-week total for the number of steps walked. For other parameters, number of steps and walking time (sec) were measured while subjects freely walked 5 m. These measurements were used to calculate stride length (cm) and walking speed (m/sec). The time (sec) required to climb 15 stairs in a stairway within the facility (step height 17 cm) was also measured with the subjects climbing at a natural pace. Furthermore, to understand the indirect factors such as balance and agility that may control walking, tests were conducted on the subjects' ability to stand on one leg with eyes open and closed, and jumping reaction time (the time it took for subjects to react by jumping with both feet off a pad after seeing a

flash of light).

For a self-evaluation of present state of health, each of the subjects responded verbally to questions such as "Do you think you are currently healthy?", and were then graded on a 4-step scale (4 = healthy, 3 = fairly healthy, 2 = not very healthy, and 1 = not at all healthy).

Statistical analysis

Simple categorized totals were calculated for all results, and each was carefully considered. To understand whether the measured items changed with age, reference was made to other reports⁹⁾ and subjects were divided into 3 age groups: 65-74 years old (N=22), 75-84 years old (N=33), and 85 years old and above (N=12). These ages were chosen with consideration of the age at which people may enter the institution (65 years old), the mean age of all subjects (79 years old, with a central value placed on mean age), and the fact that some residents were above 85 years old. A simultaneous test between groups was done by single configuration analysis.

Simple totals were calculated for all results, and the results of each measurement were investigated. Stride length (cm) and walking time (m/s) were then calculated from the number of steps (5m) and walking time (5m), and were analyzed for relations. Next, a correlation matrix was used to determine which of the measured items were closely related. Furthermore, to clarify relationships with variables other than total number of steps walked, total steps was taken as the dependent variable and a multiple regression analysis was performed with other variables as the independent variables.

Results

A. Changes with age

The measurement results for each age group are shown in Table 1. Changes with age were found in most of the items measured. Specifically, statistically significant changes were observed between the groups in height, jumping reaction time, total walking steps (1 week), walking speed, stride length and the time taken to climb 15 steps.

B. Relationship between total number of steps walked and each measured item

Table 2 shows a correlation matrix for all the items measured. Looking at the relation between total number of steps

Table 1 Results of statistical analysis of various age groups.

	65-74 N=22	75-84 N=33	85- N=12	F-value
	Mean $\pm$ SE	Mean $\pm$ SE	Mean $\pm$ SE	P<
Age	71 $\pm$ 1	80 $\pm$ 1	88 $\pm$ 1	0.00
Height (cm)	148.0 $\pm$ 1.4	147.0 $\pm$ 1.6	142.4 $\pm$ 1.6	0.02
Weight (kg)	46.9 $\pm$ 1.4	47.4 $\pm$ 1.5	43.7 $\pm$ 2.3	0.39
BMI (W(kg)/H(m) ²)	21.44 $\pm$ 0.61	21.57 $\pm$ 0.64	21.49 $\pm$ 1.08	0.99
Jumping reaction time (sec)	0.534 $\pm$ 0.001	0.723 $\pm$ 0.100	1.021 $\pm$ 0.211	0.00
Standing on one leg with eyes-closed (sec)	4.0 $\pm$ 0.9	2.4 $\pm$ 0.4	1.7 $\pm$ 0.3	0.08
Standing on one leg with eyes- open (sec)	8.2 $\pm$ 1.7	5.3 $\pm$ 1.5	2.5 $\pm$ 0.7	0.16
Walking steps total (/week)	46508 $\pm$ 4616	29185 $\pm$ 2645	16292 $\pm$ 3605	0.00
Walking speed (m/sec)	1.04 $\pm$ 0.06	0.79 $\pm$ 0.06	0.69 $\pm$ 0.05	0.00
Stride length (cm)	55.74 $\pm$ 2.39	47.55 $\pm$ 1.93	39.83 $\pm$ 2.44	0.00
Stair-Climbing time (15 steps) (sec)	11.2 $\pm$ 1.2	14.9 $\pm$ 1.5	21.7 $\pm$ 3.4	0.00
Self-rated health (4 step scale)	3.1 $\pm$ 0.3	2.8 $\pm$ 0.3	2.3 $\pm$ 0.4	0.28

walked and the other measured items, a negative correlation was seen between total number of steps and age ($r=-0.543$, $P<0.01$), stair-climbing time ($r=-0.501$, $P<0.01$), jumping reaction time ($r=-0.258$, $P<0.05$). However, a positive correlation was found between total number of steps and stride length ($r=0.408$, $P<0.01$), walking speed ($r=0.419$, $P<0.01$), self-rated health ($r=0.390$, $P<0.05$) and standing on one leg with eyes closed ($r=0.258$, $P<0.05$).

C. Relationship between total number of steps walked and physical strength factors

Table 3 shows the results of a multiple regression analysis with total number of steps (1 week) as the dependent variable and the other measured items of physique or strength as the independent variables. The multiple correlation coefficient exhibited a high value of $R = 0.723$ ($F = 5.263$, $P<0.01$). With P values, however, no significant relation was seen between self-rated health, stride length, walking speed, height, weight, BMI, jumping reaction time, or standing on one leg with eyes open. To improve repeatability, the multiple regression analysis was done again, this time excluding the items above for which there was no significant difference other than those with a strong correlation to total number of steps walked. However, the purpose was to clarify the relationship of number of steps walked, and physical factors thought to be related to it, with measurements of self-rated health. thus, a second multiple regression analysis was

performed, this time with self-rated health, for which no significant difference was found, as the control variable. The results showed number of steps walked to be related to age, self-rated health, stair-climbing time, and standing on one leg with eyes closed ($R=0.696$), ($F=11.552$, $P<0.01$).

The results of this second analysis demonstrated a strong correlation between the total number of steps walked and physical factors such as balance, as well as a correlation between number of steps and health awareness.

Discussion

Care Houses are based on the premise of self-reliance, and walking ability is an important physical factor for that self-reliance. This can be understood by the strong relationship between ADL⁽¹⁰⁾ ability and walking ability^(11,12).

With elderly Care House residents as subjects, the present study investigated whether the number of steps could be used as an indicator of related physical factors as well as of self-rated health. Similar to earlier studies⁽¹³⁻¹⁵⁾ among elderly care house residents, a statistically downward trend with time was observed in height, jumping reaction time, total number of steps walked, walking speed, and stride length. This decline, however, is not linear. The downward slope in height, jumping reaction time, and stair-climbing time is slight through the 70s, then beginning in the early 80s declines rapidly with age.

Doherty et al⁽⁶⁾ reported that motor unit losses are a primary factor in the age-associated reductions in contractile strength. Recent studies^(17,18) have indicated that the deterioration in muscle

Table 2 Correlation matrix of all measured items. (N=67)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Age	1.000	-0.323*	-0.237	-0.091	0.361*	-0.345*	-0.313	-0.543**	-0.515**	-0.511**	0.410*	-0.233
(2) Height		1.000	0.381*	-0.145	-0.264	0.010	0.149	0.142	0.356*	0.098	-0.210	-0.052
(3) Weight			1.000	0.856**	-0.202	0.014	-0.233	0.130	0.227	0.097	-0.086	-0.074
(4) BMI				1.000	-0.091	0.013	-0.309	0.063	0.072	0.067	-0.001	-0.047
(5) Jumping reaction time					1.000	-0.172	0.006	-0.258*	-0.410**	-0.388*	0.727**	-0.238
(6) SOL with EC						1.000	0.651**	0.258*	0.086	0.397*	0.236	-0.152
(7) SOL with EO							1.000	0.106	0.115	0.291*	-0.125	-0.047
(8) Walking Steps total								1.000	0.408**	0.419**	-0.501**	0.390*
(9) Stride length									1.000	0.756**	-0.735**	0.222
(10) Walking speed										1.000	-0.612**	0.250
(11) Stair-climbing time (15 steps)											1.000	-0.354*
(12) Self-rated health												1.000

SOL with EC: Standing on one leg with eyes-closed, EO: Eyes-open, *, $P<0.05$, **, $P<0.01$

Table 3 Multiple regression analysis of a factor influencing total walking steps as a dependent variable.

Significant differences among all variables were calculated as assumed influences of total walking steps (1 week) (N=67).

The right side shows the results excluding influence of Length of steps, Walking speed, Height, Weight, BMI, Jumping reaction time and Standing on one leg with eyes-open from the independent variable (N=67).

and standing on one leg with eyes open from the independent variable (F=6.7%).			
Multiple correlation coefficient	0.723(F=5.263**)		0.696(F=11.552**)
Coefficient of multiple determination	0.522		0.484
	P		P
Age	0.001	Age	0.001
Self-rated health	0.095	Self-rated health	0.024
Stride length	0.825	Stair-climbing time (15 steps)	0.001
Walking speed	0.405	Standing on one leg with eyes-closed	0.048
Stair-climbing time (15 steps)	0.001		
Height	0.110		
Weighth	0.117		
BMI	0.120		
Jumping reaction time	0.669		
Standing on one leg with eyes-closed	0.049		
Standing on one leg with eyes-open	0.763		

**; $P<0.01$

strength which accompanies age progresses rapidly through the 50s and 60s. In the present study, however, different results were obtained. This suggests that there are some elderly who maintain muscle strength (walking speed, stair-climbing time, etc.), and thus extend their lives, through activities related to daily life.

Changes with age in agility and balance ability were observed in the total reaction test, standing on one leg with eyes shut, and standing on one leg with eyes open. Levin and Benton¹⁾ maintain that the decline in agility and balance with age is a complex phenomenon in which the decrease in the number of nerve cells, the decline in nerve impulse transmission velocity, and the deterioration of cognitive function all play a part. Kaneko¹⁹⁾ suggested that the deterioration of neuromuscular function contributes to the decline with age in walking ability. These findings suggest that the changes in agility, balance, and walking ability have common causative factors in the deterioration of neuromuscular function, including the brain. It has also been suggested that the changes in ability to stand on one leg with eyes open and with eyes closed are due at least in part to deterioration of muscle function in the legs²⁰⁾.

These phenomena are closely related to falls among the elderly^{21,22)}. Agility, balance, and the number of steps walked in daily life can thus be considered important factors for investigation in order to prevent falls among residents of institutions for the elderly. Age is not the only factor related to the number of steps walked; leg muscle strength, balance and other factors are also important. Rikli et al⁴⁾ reported the effectiveness among older women of long-term regular exercise in improving ability to stand on one leg with eyes open and response time, and that aerobic exercise increased cognitive processing speed which had previously deteriorated.

The present study as well shows that the amount of walking plays a role in agility and balance. It is therefore thought that ensuring a regular amount of walking (number of steps) will contribute to maintaining these functions as well as to increasing cognitive function.

Leg muscle strength and balance ability are also reflected in stride length and stair-climbing time²³⁾. Jette et al²⁾ reported that walking exercise improves this type of physical strength. Moreover, Takeshima et al⁶⁾ found that the self-rated evaluations of endurance and health is determined in large part by the amount one moves one's own body. Arao et al²³⁾ understood "functional fitness" as the physical capacity required for the elderly to carry on with daily life, and maintain that walking ability is a key behavior for this.

Consideration of the above suggests that a walking habit among the elderly is an important element in leading an active daily life, and furthermore that it can serve as an indicator of the physical capacities related to balance and leg muscle strength, as well as subjective feelings of health. In the present study, correlations were found between stair-climbing time as a reflection of amount of the walking and leg muscle strength, and the test of standing on one leg with eyes closed and self-rated health as a reflection of balance. This suggests that the amount of walking by elderly persons, as measured by number of steps, can serve as an indicator for the degree of various aspects of physical strength and in understanding the state of health.

The above shows that understanding the number of steps walked, which is deeply connected to daily activities among the elderly, can be important in gaining an objective understanding of the level of physical strength as it deteriorates with age. In addition, ensuring a certain level of walking can be a key factor in leading a healthy life among the elderly.

The above indicates that a walking habit among elderly people contributes to cognitive function and to preventing the deterioration of related physical strength, and at the same time to increasing the opportunities for leading an active life. From this one may see the importance of locating institutions such as the one in the present study in areas that provide a social environment, such as being close to shopping or other outing destinations, to encourage the habit of walking among the elderly.

References

- 1) Levin HS Benton AL. Age effects in proprioceptive feedback performance. *Geront Clin* 1973; 15:161-9.
- 2) Jette M, Sidney K, Campbell J. Effects of a twelve-week walking programme on maximal and submaximal work output indices in sedentary middle-aged men and women. *J Sports Med* 1988; 28:59-66.
- 3) Paffenbarger RS. Jr, Hyde RT, Wing AL, Lee I-Min, Jung D L, Kampert JB. The association of changes in physical activity level and other lifestyle characteristics with mortality among men. *The New Eng J of Med* 1993; 328:538-45.
- 4) Rikli RE, Edwards DJ. Effects of a three-year exercise program on motor function and cognitive processing speed in older women. *RQES* 1991; 62:61-7.
- 5) Pollock ML, Foster C, Knapp DJ, Schmidt DH. Effect of age and training on aerobic capacity and body composition of master athletes. *J Appl Physiol* 1987; 62:725-31.
- 6) Takeshima N, Tanaka K, Kobayashi F, Watanabe T, Nakata M. Effects of walking habit on aerobic work capacity and vital age in middle-aged and elderly walkers. *Jpn J Phys Fitness Sports Med* 1996; 45:387-94.
- 7) New PK, Ruscio AT, Priest RP, Petritsi D, Geoug LA. The support structure of heart and stroke patients. A study on the rouge of significant other in patients rehabilitation. *Soc Sci Med* 1968; 2:185-200.
- 8) Ootuka T. Use of pedimeters from the viewpoint of sports medicine. (in Japanese) *Jpn J Clinical Sports Medicine* 1992; 9:143-7.
- 9) Tujii I, Minami Y, Penelope MK, Hisamichi S, Asano H, Sato M. The predictive power of daily living and ambulatory activity for cause-specific mortality among the elderly: A tree-year follow-up in urban Japan. *Am Geriatrics Soci* 1994; 42:153-6.
- 10) Sidney K, Downs TD, Cash HR, Grotz RC. Progress in development of the index of ADL. *Gerontologist* 1970; 1:20-30.
- 11) Shibata, H, Haga H, Nagai H, et al. Predictors of all-cause mortality between ages 70 and 80: The Koganei study. *Arch Gerontol Geriatr* 1992; 14:283-97.
- 12) Terasaki H, Umesato Y, Kubo Y, Ohmichi H. A comparative study on long-term care facilities for the aged in Japan. *Jpn Society of Public Health* 1994; 41:671-81.
- 13) Sato T, Murase T, Fujii T, Iwao S, Kobayashi Y, Sato Y.

- Relationship of health and physical fitness in middle-aged and elderly men and women. *Jpn J Phys Fitness Sports Med* 1996; 45:357-64.
- 14) Furuna T, Nagasaki H, Ito H, Hashizume K, Kinugasa T, Maruyama H. Motor abilities of older adults in Japanese urban and rural communities. *Jpn J Phys. Fitness Sports Med* 1995; 44:347-56.
 - 15) Matubayashi K, Okimura K, Wada T, et al. Comparative study of activity of daily living in the elderly between in Kahoku and in Yaku. *Jpn J Geriat Soci* 1994; 31:759-67.
 - 16) Doherty JT, Vandervoort AA, Taylor AW, Brown WF. Effects of motorunit losses on strength in older men and women. *J Appl Physiol* 1993; 74(2):868- 74.
 - 17) Bemben MG, Massey BH, Bemben DA, Misner JE, Boileau RA. Isometric muscle force production as a function of age in healthy 20-to 74-yr-old men. *Med Sci Sports Exerc* 1991; 23:1302-10.
 - 18) Fishen NM, Pendergast DR, Calkins EC. Maximal isometric torque of knee extension as a function of muscle length in subjects of advancing age. *Arch Phys Med Rehabil* 1990; 71:729-34.
 - 19) Kaneko M, Morimoto Y, Kimura M, Fuchimoto K, Fuchimoto T. A kinematic analysis of walking and physical fitness testing in elderly women. *Can J Sport Sci* 1991; 16:223-8.
 - 20) Kimura M, Tokuhiko M, Okayama Y, Okuno T, Nakao T. Evaluation of balance function in the aged using closed-eye and open-eye one-foot balancing test. Report of Research Center for Physical Education. 1996; 24:118-29.
 - 21) Haga H, Shibata H, Shichita K, Matsuzaki T, Hatano S. Falls in the institutionalized elderly in Japan. *Gerontol Geriatr* 1986; 5:1-9.
 - 22) Campbell AJ, Borrie MJ, Spears GF. Risk factors for falls in a community. based prospective study of people 70 years and older. *J Gerontol* 1989; 44:112-7.
 - 23) Arao T, Oida Y, Nagamatsu T. Functional fitness and related factors in community-dwelling elderly. *Jpn Society of Public Health* 1998; 45:396-406.