Author Contributions: All authors contributed to the design and conduct of the "Otasha-kenshin." Jinhee Kwon was involved in study conceptualization, analysis and collection of data, interpretation of data, and writing manuscript. Takao Suzuki was involved in study conceptualization, interpretation of data, manuscript preparation, critical revision of the manuscript for import intellectual content, and supervision. Hideyo Yoshida, Hunkyung Kim, Yuko Yoshida, Hajime Iwasa, Miho Sugiura, and Taketo Furuna were involved in collection of data, interpretation of data, and critical revision of the manuscript for import intellectual content.

Sponsor's Role: None.

REFERENCES

1. Pearlman RA, Uhlmann RF. Quality of life in elderly chronically ill outpatients. J Gerontol A Biol Sci Med Sci 1991;46A:M31–M38.
2. Karinkanta S, Heinonen A, Sievänen H et al. Factors predicting dynamic balance and quality of life in home-dwelling elderly women. Gerontology 2005;51:116–121.
3. Shinkai S, Watanabe S, Kumagai S et al. Walking speed as a good predictor for the onset of functional dependence in a Japanese rural community population. Age Ageing 2000;29:441–446.
4. Suzuki T, Yoshida H, Kim H et al. Walking speed as a good predictor for maintenance of I-ADL among the rural community elderly in Japan: A 5-year follow-up study from TMIG-LISA. Geriatr Gerontol Int 2003;3:S6–S14.
5. Guralnik JM, Ferrucci L, Pieper CE et al. Lower extremity function and subsequent disability: Consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci 2000;55A:M221–M231.
6. Rantanen T, Guralnik JM, Ferrucci L et al. Coimpairment as predictors of severe walking disability in older women. J Am Geriatr Soc 2001;49:21–27.
7. Ferrucci L, Guralnik JM, Buchner D et al. Departures from linearity in the relationship between measured of muscular strength and physical performance of the lower extremities: The women's health and aging study. J Gerontol A Biol Sci Med Sci 1997;52A:M275–M285.
8. Sugiura M, Nagasaki H, Furuna T et al. Walking ability of older adults in the community—a four-year follow-up study. Jpn J Phys Fitness Sports Med 1998;47:443–452 (in Japanese with English summary).
9. Taaffe DR, Simonsick EM, Visser M et al. Lower extremity physical performance and hip bone mineral density in elderly black and white men and women: Cross-sectional associations in the Health ABC study. J Gerontol A Biol Sci Med Sci 2003;58A:M934–M942.
10. Blain H, Vuillemin A, Teissier A et al. Influence of muscle strength and body weight and composition on regional bone mineral density in healthy women aged 60 years and over. Gerontology 2001;47:207–212.
11. Sirola J, Tuppurainen M, Honkanen R et al. Associations between grip strength change and axial postmenopausal bone loss—a 10 year population-based follow-up study. Osteoporos Int 2005;16:1841–1848.
12. Lindsey C, Brownbill RA, Bohannon RA et al. Association of physical performance measured with bone mineral density in postmenopausal women. Arch Phys Med Rehabil 2005;86:1102–1107.
13. Suzuki T, Iwasa H, Yoshida H et al. Comprehensive health examination ('Otasha-Kenshin') for the prevention of geriatric syndromes and a bed-ridden state in the community elderly. 1. Difference in characteristics between participants and non-participants. Jpn Public Health 2003;50:39–48 (in Japanese with English summary).
14. Iwasa H, Suzuki T, Yoshida H et al. Cognitive function as the factor determining higher-level competence in community-dwelling elderly: Comprehensive health examination for the community elderly for the prevention of the geriatric syndrome and a bed-ridden state ('Otasha-Kenshin'). Jpn J Public Health 2003;50:950–958 (in Japanese with English summary).
15. Duncan PW, Weiner DK, Chandler J et al. Functional reach: A new clinical measure of balance. J Gerontol 1990;45:192–197.
16. Koyano W, Shibata H, Nakazato K et al. Measurement of competence: Reliability and validity of the TMIG index of competence. Arch Gerontol Geriatr 1991;13:103–116.
17. Puggaard L. Effects of training on functional performance in 65, 75, and 85 year-old women: Experiences deriving from community based studies in Odense, Denmark. Scand J Med Sci Sports 2003;13:70–76.
18. Scognamiglio R, Piccolotto R, Negut C et al. Oral amino acids in elderly subjects: Effect on myocardial function and walking capacity. Gerontology 2005;51:302–308.
19. Riggs BL, Wahner HW, Melton LJ et al. Rates of bone loss in the appendicular and axial skeletons of women: Evidence of substantial vertebral bone loss before menopause. J Clin Invest 1986;77:1487–1491.
20. Devine A, Dick IM, Islam A et al. Protein consumption is an important predictor of lower limb bone mass in elderly women. Am J Clin Nutr 2005;81:1423–1428.
21. Nguyen TV, Center JR, Eisman JA. Osteoporosis in elderly men and women: Effects of dietary calcium, physical activity, and body mass index. J Bone Miner Res 2000;15:322–331.
22. Pongchaiyakul C, Nguyen TV, Kosulwat V et al. Effects of physical activity and dietary calcium intake on bone mineral density and osteoporosis risk in a rural Thai population. Osteoporos Int 2004;15:807–813.
23. Kaptoge S, Welch A, McTaggrt A et al. Effects of dietary nutrients and food groups on bone loss from the proximal femur in men and women in the 7th and 8th decades of age. Osteoporos Int 2003;14:418–428.
24. Meier C, Woitge HW, Witte K et al. Supplementation with oral vitamin D3 and calcium during winter prevents seasonal bone loss: A randomized controlled open-label prospective trial. J Bone Miner Res 2004;19:1221–1230.
25. Going S, Lohman T, Houtkooper L et al. Effects of exercise on bone mineral density in calcium-replete postmenopausal women with and without hormone replacement therapy. Osteoporos Int 2003;14:637–643.
26. Shepherd JA, Cheng XG, Lu Y et al. Universal standardization of forearm bone densitometry. J Bone Miner Res 2002;17:734–745.
27. Nakamura K, Saito T, Nishiwaki T et al. Correlations between bone mineral density and demographic, lifestyle, and biochemical variables in community-dwelling Japanese women 69 years of age and over. Osteoporos Int 2006;17:1202–1207.
28. Mulder JE, Michaeli D, Flaster E et al. Comparison of bone mineral density of the phalanges, lumbar spine, hip, and forearm for assessment of osteoporosis in postmenopausal women. J Clin Densitom 2000;3:373–381.

Available online at www.sciencedirect.com

ScienceDirect

ELSEVIER

Archives of Gerontology and Geriatrics 44 (2007) 163–173

ARCHIVES OF GERONTOLOGY AND GERIATRICS

www.elsevier.com/locate/archger

Effects of exercise frequency on functional fitness in older adult women

Yoichi Nakamura[a,c,*], Kiyoji Tanaka[a], Noriko Yabushita[a], Tomoaki Sakai[a], Ryosuke Shigematsu[b]

[a] *Comprehensive Human Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba City, Ibaraki 305-8574, Japan*
[b] *Faculty of Education, Mie University, 1515 Kamihama, Tsu City, Mie 514-8507, Japan*
[c] *Japan Health Promotion & Fitness Foundation, 1-25-5 Toranomon, Minato-ku, Tokyo 105-0001, Japan*

Received 3 October 2005; received in revised form 18 April 2006; accepted 21 April 2006
Available online 30 May 2006

Abstract

This study evaluated the effects of exercise frequency on functional fitness in older women participating in a 12-week exercise program. Participants (67.8 ± 4.6 years) were divided into three different exercise groups (I, II, and III; $n = 34$) and a control group (Group C; $n = 11$). Group I participated in a 90-min exercise program once a week, for 12 weeks, while Group II attended it twice a week, and Group III attended three times a week. The exercise program consisted of a 10-min warm-up, 20 min of walking, 30 min of recreational activities, 20 min of resistance training, and a 10-min cool-down. The following items were measured before and after the program: muscular strength, muscular endurance, dynamic balance, coordination, and cardiorespiratory fitness (6-min walking distance). Comparisons of baseline and post-intervention measures showed significantly greater improvements in body weight, coordination, and cardiorespiratory fitness for Group III compared to the other groups ($p < 0.05$). In addition, the greatest improvements in body fat, muscular endurance, and dynamic balance were also observed in Group III ($p < 0.05$). However, no significant differences were found in muscular strength. Older women who participate in an exercise program three times a week gain greater functional fitness benefits than those who exercise less frequently. In order to improve functional fitness in older women, an exercise frequency of at least three times each week should be recommended.

Keywords: Exercise of older women; Functional fitness; Frequency of exercise

* Corresponding author. Tel.: +81 3 3591 7258; fax: +81 3 3591 7155.
E-mail address: ex-db@health-net.or.jp (Y. Nakamura).

0167-4943/$ – see front matter
doi:10.1016/j.archger.2006.04.007

1. Introduction

Advancing age is generally accompanied by a progressive decline in physical activity (Evans and Meredith, 1989). Age-related decline has been documented for functional fitness; including muscular strength, flexibility, balance, agility, gait velocity, and cardiorespiratory fitness (Raab et al., 1988; Rikli and Edwards, 1991). For years, performance decline in these areas was thought to be a normal and necessary consequence of aging. Previous studies, however, indicate that decline relates more to lifelong physical activity levels than to age. Physically active older women, for instance, were found to have performance patterns of flexibility, balance, and agility more similar to younger participants than to their older inactive pairs (Rikli and Busch, 1986). Based on these findings, interest in examining the relationship between musculoskeletal health and exercise in older adults has emerged (Vuori, 1995). Especially for women, muscle mass, muscular strength, muscular endurance, and cardiorespiratory fitness are important components of functional fitness; they are also the major causes of limited mobility and activity (Rantanen et al., 1994). Therefore, it is important for older women to exercise regularly to maintain and to recover functional fitness.

There are many reports which indicate that exercise intervention for older women produces an improvement in functional fitness. Nichols et al. (1995) have reported significant strength improvement in men and women over 60 who followed a strength training program twice a week for 12 weeks. Brown and Holloszy (1993) have reported significant differences in the flexibility of older participants who followed a training program twice a week for 12 weeks, and Wolfson et al. (1996) state that elderly individuals participating in a training program three times a week can significantly improve their dynamic balance after 12 weeks. According to these studies, exercise more than twice a week seems to improve functional fitness. However, only a few attempts have so far been made to establish how frequently older adults should exercise in order to improve their functional fitness.

Our aim was to evaluate the effects of exercise frequency on body composition and functional fitness in older women participating in a 12-week exercise program, to identify the minimum frequency per week required to produce significant results for the selected items.

2. Subjects and methods

2.1. Participants

Participants in this study were 45 healthy sedentary women (67.8 ± 4.6 years of age) living independently. Participants were permanent residents in Ibaraki prefecture who had not been involved in any physical activity for at least 6 months before the exercise program began. The study was approved by the Institutional Review Board of University of Tsukuba. All patients signed the informed consent form. According to their place of residence, they were divided into three different exercise groups (Group I; n = 10, Group II;

$n = 10$, and Group III: $n = 14$) and a control group (Group C; $n = 11$). Group I participated in a 90-min exercise program once a week, for 12 weeks, while Group II attended the program twice a week, and Group III attended three times a week.

2.2. *Anthropometry and body composition*

Body height was measured to the nearest 0.1 cm. Weight was assessed to the nearest 0.1 kg using a beam scale. Body fat was determined using bioelectrical impedance (SS-103) (Sekisui Chemical Co., Ltd.). Body mass index (BMI) was calculated by dividing weight (kg) by height (m) squared (kg/m^2).

2.3. *Functional fitness test items*

Items were selected to address comprehensively each area of the instrumental activities of daily living (IADL) for older adults (Osness, 1989; Duncan et al., 1990; Kim and Tanaka, 1995; Shigematsu and Tanaka, 2000). IADL are related to complex physical abilities, such as light house-cleaning activities, preparing dinner, making beds, washing and ironing clothes, shopping, and walking (Spirduso, 1995). In this study, we selected six items, which are high in relation to IADL. The six functional fitness test items, the physical elements, and the methods used are as follows:

(i) Hand gripping (muscular strength): the subject was instructed to hold a hand-grip dynamometer (Takei Industrial, Grip-D) in the dominant hand, and to try gripping it with maximum effort while keeping the dominant hand away from the body. Performance was recorded in units of 0.1 kg.
(ii) Arm curl (muscular endurance): the subject was instructed to sit on a chair and then use the dominant hand to bring a weight (2.0 kg) up and down (flex and extend the biceps) as many times as possible in 30 s. Performance was assessed on the frequency of repetitions.
(iii) Sit-and-stand (muscular endurance): the subject was instructed to sit on a chair, back straight, feet shoulder-width apart and flat on the floor, and arms crossed at the wrists and held against the chest. On the signal, the subject rises to a full stand and then returns to a fully seated position. The subject is encouraged to complete as many full stands as possible within 30 s.
(iv) Reaching arms forward in a standing position (functional reach) (dynamic balance): the subject was asked to stand and then raise both arms to shoulder level. Performance was assessed on the maximal distance the subject could reach forward beyond her own arm's length, while the heels remained touching the ground.
(v) Walking around two cones (coordination): the subject was asked to sit in a chair located between two cones, which were placed 1.8 m on either side of and 1.5 m behind the chair. On the signal, the subject rose from the chair, walked to her right going to the inside and around the back of the cone (counterclockwise), returned to a fully seated position on the chair, walked around the other cone (clockwise), and returned to a fully seated position. One trial consisted of two complete circuits. Performance time was recorded in units of 0.1 s.

(vi) Six-minute walk distance (cardiorespiratory fitness): the test involves assessing the maximum distance that can be walked in 6 min along a 50 m course marked out in 5 m segments. The subject is instructed to walk as fast as possible (without running) around the course as many times as she can in 6 min. The score is the total number of meters walked in 6 min, to the nearest 5 m. Test administrator records the nearest 5 m mark.

The tests were all checked for reliability and validity during fitness demonstration with the elderly (Shigematsu et al., 1998; Jones et al., 1999; Enright, 2003).

2.4. The exercise program

The three experimental groups participated in the 12-week intervention program once, twice, or three times a week (Groups I, II, and III, respectively). Each exercise session lasted approximately 90 min. The exercise program consisted of a 10-min warm-up, 20 min of walking, 30 min of recreational activities, 20 min of resistance training, and a 10-min cool-down. The intensity of the walking session was approximately 13 of the rating of perceived exertion (RPE) during the session. In recreational activities, we demonstrated elements of balance, agility, and coordination using a rubber ball (diameter 10–20 cm), a Slomo® Ball (diameter 20–40 cm), a soft valley ball (diameter 30–50 cm), and a Gymnic® ball (diameter 60–80 cm). In resistance training, we demonstrated push ups, leg squats, sit ups, and back extensions using self-weight or a Thera-Band® tube. During the resistance training sessions, the participants performed three sets of 10 repetitions with a 30-s rest between sets. The control group (Group C) did not follow any exercise program.

2.5. Statistical analysis

Statistical analyses of the data began with calculations of the arithmetic means and standard deviations (±S.D.). The effects of training were assessed using the two-way analysis of variance (ANOVA) with repeated measures. If the significance of the interaction of group by time in ANOVA with repeated measures had a $p < 0.05$, we analyzed the differences between the groups at the baseline and the change rate before and after intervention using the one-way ANOVA. If there was a difference in change rate between groups on specific parameters at the baseline, the parameter was used as a covariate in the analysis. Post-hoc tests were carried out using the Bonferroni correction. $p < 0.05$ are considered to indicate statistical significance. Statistical analysis was performed with the Scientific Package of Sciences (SPSS) Version 11.0J for Windows PC.

3. Results

The physical activity levels of the subjects at the baseline are presented in Table 1. Significant differences were found in body fat between Groups III and C, and between Groups I and C. There was no significant difference in other baseline values of physical characteristics among the groups.

Table 1
Baseline physical characteristics of the study subjects

Variable	Group C (n = 11)	Group I (n = 10)	Group II (n = 10)	Group III (n = 14)	p-value
Age (year)	69.0 ± 4.9	65.1 ± 4.3	67.5 ± 3.6	69.1 ± 4.9	0.156
Height (cm)	148.1 ± 5.2	151.0 ± 4.4	150.4 ± 4.4	147.8 ± 5.2	0.292
Body weight (kg)	58.7 ± 8.2	56.8 ± 6.6	56.5 ± 4.7	52.2 ± 9.0	0.185
Body fat (%)	35.8 ± 3.2	31.9 ± 3.1	34.0 ± 2.6	32.2 ± 4.3	0.040[a]
BMI (kg m^{-2})	26.7 ± 2.6	24.9 ± 2.4	25.0 ± 1.6	23.9 ± 3.7	0.118

Values are presented as mean ± S.D.
[a] Significant difference between Group III and Group C ($p < 0.05$), and between Group I and Group C ($p < 0.05$).

Interaction of group by time was found for body weight, body fat, and BMI. There was a significant difference in the effect of time in body fat between Group III and Group C ($p < 0.05$). There was a significant difference in the effect of time in BMI between Group III and Group C ($p < 0.05$) (Table 2). The mean percentage changes in body weight and BMI in Groups C, I, II, and III were +1.1%, +0.4%, +0.1%, and −2.8%, respectively. The mean percentage changes in body fat were +2.0%, +0.5%, −0.3%, and −2.4% (Fig. 1).

Interaction of group by time was found for grip strength, arm curl, sit-and-stand, functional reach, walking around two cones and 6-min walk distance. There was a significant difference in the effect of time between Group II and Group C ($p < 0.05$), and Group I and Group C ($p < 0.05$). There was a significant difference in the effect of time between Group III and Group II ($p < 0.05$), and Group I ($p < 0.05$), and between Group II and Group C ($p < 0.05$), and between Group I and Group C ($p < 0.05$) (Table 3).

The mean percentage changes in grip strength in Groups C, I, II, and III were −1.1%, −1.4%, −2.1%, and +1.4%, respectively. The mean percentage changes in arm curl were −0.2%, −3.9%, −0.9%, and +7.5%. The mean percentage changes in sit-and-stand were −6.0%, −1.5%, −2.5%, and +4.4%. The mean percentage changes in functional reach were −1.9%, −3.0%, −4.5%, and +9.6%. The mean percentage changes in walking around

Table 2
Physical characteristics of the study groups before and after 12-week intervention

Variable	Group C (n = 11)	Group I (n = 10)	Group II (n = 10)	Group III (n = 14)	Two-way ANOVA			Post-hoc test
					Group	Time	Interaction	
Body weight (kg)								
Baseline	58.7 ± 8.2	56.8 ± 6.6	56.5 ± 4.7	52.2 ± 9.0	0.07	0.32	$p < 0.05$	ns
12 weeks	59.4 ± 8.4	57.0 ± 6.4	56.6 ± 4.8	50.5 ± 7.4				
Body fat (%)								
Baseline	35.8 ± 3.2	31.9 ± 3.1	34.0 ± 2.6	32.2 ± 4.3	$p < 0.05$	0.94	$p < 0.05$	C < III
12 weeks	36.5 ± 3.3	32.1 ± 3.0	34.0 ± 2.7	31.5 ± 4.7				
BMI (kg m^{-2})								
Baseline	27.0 ± 2.8	24.9 ± 2.4	25.0 ± 1.6	23.9 ± 3.7	$p < 0.05$	0.34	$p < 0.05$	C < III
12 weeks	26.7 ± 2.6	25.0 ± 2.3	25.0 ± 1.6	23.1 ± 3.1				

Values are presented as mean ± S.D.

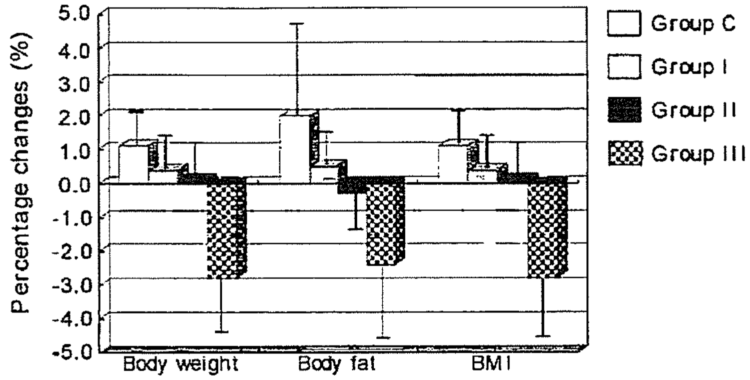

Fig. 1. Percentage changes in body weight and body fat after 12-week intervention. Significant difference in percentage changes between Group III and Group C, Group I, and Group II ($p < 0.05$) in body weight and BMI. Significant difference in percentage changes between Group III and Group C ($p < 0.05$) in body fat.

two cones were +2.5%, +2.9%, +2.3%, and −6.2%. The mean percentage changes in 6 min walk distance were −2.2%, −0.7%, −0.7%, and +4.1% (Fig. 2).

4. Discussion

In this study, we attempted to examine how frequently exercise is necessary for improving body composition and functional fitness in sedentary older women.

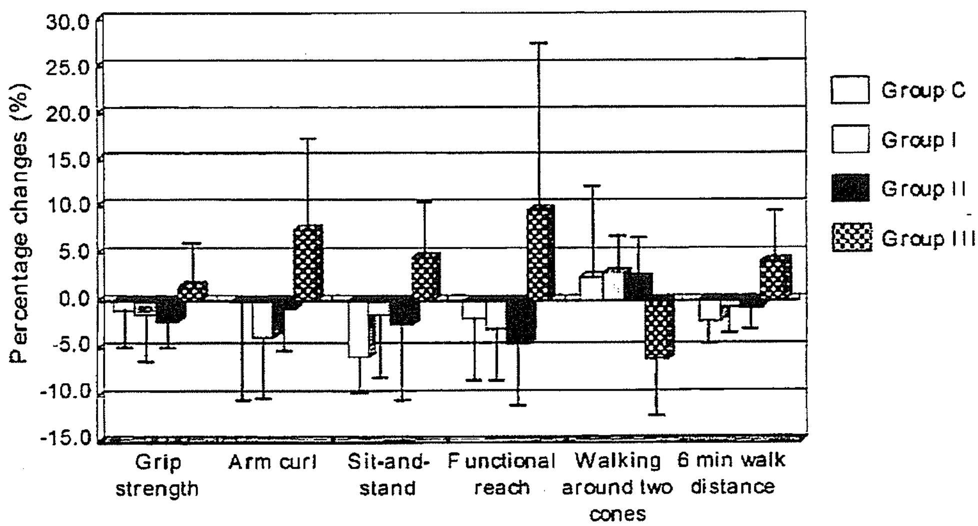

Fig. 2. Percentage changes in physical fitness after 12-week intervention. Significant difference in percentage changes between Group III and Group I ($p < 0.05$) in Arm curl. Significant difference in percentage changes between Group III and Group C ($p < 0.05$) in Sit-and-stand. Significant difference in percentage changes between Group III and Group I, and Group II ($p < 0.05$) in functional reach. Significant difference in percentage changes between Group III and Group C, Group I, and Group II ($p < 0.05$) in walking around two cones and 6 min walk distance.

Table 3
Functional fitness of the study groups before and after 12-week intervention

Variable	Group C ($n = 11$)	Group I ($n = 10$)	Group II ($n = 10$)	Group III ($n = 14$)	Two-way ANOVA			Post-hoc test
					Group	Time	Interaction	
Grip strength (kg)								
Baseline	26.3 ± 2.9	27.5 ± 6.2	25.7 ± 1.6	23.6 ± 3.8	0.19	0.16	0.28	–
12 weeks	25.9 ± 2.7	27.2 ± 6.6	25.2 ± 1.7	23.9 ± 3.8				
Arm curl (cm)								
Baseline	23.6 ± 3.6	24.4 ± 4.0	22.8 ± 3.0	21.6 ± 2.2	0.61	0.80	$p < 0.05$	ns
12 weeks	23.5 ± 4.1	23.5 ± 4.2	22.5 ± 2.4	23.1 ± 2.7				
Sit-and-stand (rep)								
Baseline	16.3 ± 3.1	17.7 ± 2.3	16.8 ± 1.8	17.7 ± 2.1	0.09	0.13	$p < 0.05$	ns
12 weeks	15.3 ± 2.9	17.4 ± 2.3	16.4 ± 2.4	18.4 ± 2.0				
Functional reach (cm)								
Baseline	26.7 ± 4.3	34.6 ± 4.7	33.3 ± 2.2	28.6 ± 2.9	$p < 0.05$	0.74	$p < 0.05$	C < I, II
12 weeks	26.1 ± 3.6	33.5 ± 4.6	31.7 ± 1.9	31.4 ± 5.3				
Walking around two cones (s)								
Baseline	24.8 ± 4.9	18.4 ± 3.1	17.9 ± 2.2	24.8 ± 3.6	$p < 0.05$	0.98	$p < 0.05$	C < I, II; I, II < III
12 weeks	25.4 ± 5.7	18.9 ± 3.0	18.3 ± 2.1	23.3 ± 3.8				
6 min walk distance (m)								
Baseline	530.9 ± 47.3	571.0 ± 51.5	538.0 ± 43.2	520.4 ± 59.1	0.19	0.99	$p < 0.05$	ns
12 weeks	519.1 ± 45.7	566.5 ± 45.8	534.0 ± 41.6	540.7 ± 56.4				

Values are presented as mean ± S.D.

In general, exercise training has a positive effect on body composition. Also, it is reported that aerobic and resistance training decrease body fat. Owens et al. (1999) described that aerobic training (157 beat/min, 40 min/set, five times a week, 4 months in the obese) decreased body fat. Poehlman et al. (2000) reported that resistance training (80% of 1RM, three times a week, 6 months, middle-aged women) increased FFM but not body fat. Moreover, Park et al. (2003) described that combined training (aerobic + resistance, three times a week) decreased body weight and body fat. As with those previous studies, they reported that aerobic or resistance training for more than three times a week improved body composition. Kallinen et al. (2002) also found similar results with older women. In our study, the greatest improvements in body weight, body fat, and BMI were observed in the Group III. Our intervention did not produce the improvement in body composition as reported in the previous research. However, the effect was seen in body composition for exercise done three times a week, including recreational activities. For this reason, energy expenditure was increased overall, we demonstrated exercise for 90 min, longer than the exercise duration reported by previous studies (40–60 min) (Moore, 2000; Zhang et al., 2003). Based on these results, it is suggested that older women should engage in exercise over a long period of time in order to improve body composition.

As well as improving body composition, it is important for older adults to maintain functional fitness. Voorrips et al. (1993) reported on functional fitness in three groups (sedentary, moderately active, and highly active). They showed that moderate activity is of greater value than a sedentary situation, and that higher-intensity activity is more valuable than moderate-intensity activity for body weight, BMI, flexibility, and endurance (walking). Van Heuvelen et al. (2000) reported that walking endurance, grip strength, manipulation and dynamic balance contributed significantly to the prediction of disability for older adults. Gregg et al. (2003) also concluded that increasing and maintaining physical activity levels could lengthen life for older women. This can be seen from the results of moderately active and highly active groups having continued physical activity over many years. Additionally, Bovens et al. (1993) described that high numbers of this physically fit and healthy population had fewer risk factors for cardiovascular disease than less active populations. Dargent-Molina et al. (1996) also reported that maintaining functional fitness prevented hip fracture from falls. Therefore, regular exercise, especially over a long period of time, is important for older people in order to improve functional fitness.

Various researchers have found significant improvements in a number of functional fitness areas after exercise intervention, e.g., in strength (Nichols et al., 1993), in flexibility (Rikli and Edwards, 1991), in dynamic balance (Load et al., 1996; Shumway-Cook et al., 1997), in muscular coordination (Rikli and Edwards, 1991; Bouchard and Shephard, 1994). It is thought that exercise programs certainly improve the functional fitness practiced in these reports. However, for many people functional fitness declines in older adulthood; it is not enough to improve a single function through an exercise program (American College of Sports Medicine, 1998). We made the evaluation that three exercise programs for overall physical strength will bring about an improvement in older women. It is important to examine how often the exercise is necessary, because many of the previous studies do not refer to frequency of exercise. That is why we intervened at three separate levels of the frequency of exercise program, and looked for improvement of overall functional fitness.

Regarding frequency of exercise intervention, Stiggelbout et al. (2004) evaluated the effects of an exercise program on the functional fitness of independently living older adults. According to the study, although the authors concluded that the exercise program was well suited to healthy inactive older adults, twice-a-week participation without additional regular physical activity did not improve functional fitness. Also, Puggaard (2003) reported that exercise intervention twice a week was not sufficient. Our study provided similar results and it seems logical to conclude that participation in exercise programs only twice a week is not sufficient to improve functional fitness. This indicates that older individuals should endeavor to participate in exercise at least three times a week. As a matter of fact, we assumed that a once-a-week exercise program would have an effect on overall functional fitness in older participants. However, the results suggest that it is necessary to exercise at least three times a week to improve overall functional fitness.

Acknowledgements

This research was supported in part by the Tanaka Project (1996–1999, 1999–2002) of TARA (Tsukuba Advanced Research Alliance) at the University of Tsukuba, by a Grant-in-Aid for Scientific Research from the Japan Ministry of Education, Culture, Sports, Science and Technology (1997–2000 Tanaka Project #09480011 and 2000–2003 Tanaka Project #12480005), and by the 21st century COE (Center of Excellence) program, Ministry of Education, Culture, Sports, Science and Technology (2002–2005 Nishihira Project: Promotion of health and sport scientific research.

References

American College of Sports Medicine Position Stand, 1998. Exercise and physical activity for older adults. Med. Sci. Sports. Exerc. 30, 992–1008.

Bouchard, C., Shephard, R., 1994. Physical activity, fitness and health: the model and key concepts. In: Bouchard, C., Shephard, R., Stephens, T. (Eds.), Physical Activity, Fitness and Health, International Proceedings and Consensus Statement. Human Kinetics, Champaign, Illinois, pp. 77–88.

Bovens, A.M., Van Baak, M.A., Vrencken, J.G., Wijnen, J.A., Saris, W.H., Verstappen, F.T., 1993. Physical activity, fitness, and selected risk factors for CHD in active men and women. Med. Sci. Sports Exerc. 25, 572–576.

Brown, M., Holloszy, J.O., 1993. Effects of walking, jogging and cycling on strength, flexibility, speed and balance in 60- to 72-year olds. Aging (Milano) 5, 427–434.

Dargent-Molina, P., Favier, F., Grandjean, H., Baudoin, C., Schott, A.M., Hausherr, E., Meunier, P.J., Breart, G., 1996. Fall-related factors and risk of hip fracture: the EPIDOS prospective study. Lancet 348, 145–149.

Duncan, P.W., Weiner, D.K., Chandler, J., Studenski, S., 1990. Functional reach: a new clinical measure of balance. J. Gerontol. Med. Sci. 45, M192–M197.

Enright, P.L., 2003. The six-minute walk test. Respir. Care 48, 783–785.

Evans, W.J., Meredith, C.N., 1989. Exercise and nutrition in the elderly. In: Munro, H.N., Danford, D.E. (Eds.), Nutrition, Aging, and the Elderly. Plenum Press, New York, pp. 89–126.

Gregg, E.W., Cauley, J.A., Stone, K., Thompson, T.J., Bauer, D.C., Cummings, S.R., Ensrud, K.E., Study of Osteoporotic Fractures Research Group, 2003. Relationship of changes in physical activity and mortality among older women. J. Am. Med. Assoc. 289, 2379–2386.

Jones, C.J., Rikli, R.E., Beam, W.C., 1999. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res. Q. Exerc. Sport 70, 113–119.

Kallinen, M., Sipila, S., Alen, M., Suominen, H., 2002. Improving cardiovascular fitness by strength or endurance training in women aged 76–78 years. A population-based, randomized controlled trial. Age Ageing 31, 247–254.

Kim, H.S., Tanaka, K., 1995. The assessment of functional age using "Activities of daily living" performance tests: a study of Korean women. J. Aging Phys. Activity 3, 39–53.

Load, S.R., Ward, J.A., William, P., 1996. Exercise effect on dynamic stability on older women: a randomized controlled trial. Arch. Phys. Med. Rehabil. 77, 232–236.

Moore, M.S., 2000. Interactions between physical activity and diet in the regulation of body weight. Proc. Nutr. Soc. 59, 193–198.

Nichols, J.F., Omizo, D.K., Peterson, K.K., Nelson, K.P., 1993. Efficacy of heavy-resistance training for active women over sixty: muscular strength, body composition, and program adherence. J. Am. Geriatr. Soc. 41, 205–210.

Nichols, J.D., Hitzberger, L.M., Sherman, J.G., Patterson, P., 1995. Effects of resistance training on muscular strength and functional abilities of community dwelling older adults. J. Aging Phys. Activity 3, 238–250.

Osness, W.H., 1989. Assessment of physical function among older adults. In: Leslie, D.K. (Ed.), Mature Stuff: Physical Activity for the Older Adult. American Alliance for Health, Physical Education, Recreation, and Dance, Virginia, pp. 93–118.

Owens, S., Gutin, B., Allison, J., Riggs, S., Ferguson, M., Litaker, M., Thompson, W., 1999. Effect of physical training on total and visceral fat in obese children. Med. Sci. Sports Exerc. 31, 143–148.

Park, S.K., Park, J.H., Kwon, Y.C., Kim, H.S., Yoon, M.S., Park, H.T., 2003. The effect of combined aerobic and resistance exercise training on abdominal fat in obese middle-aged women. J. Physiol. Anthropol. 22, 129–135.

Poehlman, E.T., Dvorak, R.V., DeNino, W.F., Brochu, M., Ades, P.A., 2000. Effects of resistance training and endurance training on insulin sensitivity in non-obese, young women: a controlled randomized trial. J. Clin. Endocrinol. Metab. 85, 2463–2468.

Puggaard, L., 2003. Effects of training on functional performance in 65, 75 and 85 year-old women: experiences deriving from community based studies in Odense, Denmark. Scand. J. Med. Sci. Sports 13, 70–76.

Raab, D.M., Agre, J.C., McAdam, M., Smith, E.L., 1988. Light resistance and stretching exercise in elderly women: effect upon flexibility. Arch. Phys. Med. Rehabil. 69, 268–272.

Rantanen, T., Era, P., Heikkinen, E., 1994. Maximal isometric strength and mobility among 75-year-old men and women. Age Ageing 23, 132–137.

Rikli, R.E., Busch, S., 1986. Motor performance of women as a function of age and physical activity level. J. Gerontol. 41, 645–649.

Rikli, R.E., Edwards, D.J., 1991. Effects of a three-year exercise program on motor function and cognitive processing speed in older women. Res. Q. Exerc. Sport. 62, 61–67.

Shigematsu, Y., Tanaka, K., 2000. Age scale for assessing functional fitness in older Japanese ambulatory women. Aging Clin. Exp. Res. 12, 256–263.

Shigematsu, R., Kim, H.K., Kim, H.S., Tanaka, K., 1998. Reliability and objectivity of the test items to assess functional fitness required for performing activities of daily living in older adult Japanese women. Jpn. J. Physiol. Anthrop. 3, 13–18.

Shumway-Cook, A., Gruber, W., Baldwin, M., Liao, S., 1997. The effect of multi-dimensional exercises on balance, mobility, and fall risk in community-dwelling older adults. Phys. Ther. 77, 46–57.

Spirduso, W.W., 1995. Physical Dimensions of Aging. Human Kinetics, Champaign, Illinois, pp. 135–151.

Stiggelbout, M., Popkema, D.Y., Hopman-Rock, M., De Greef, M., Van Mechelen, W., 2004. Once a week is not enough: effects of a widely implemented group based exercise programme for older adults; a randomized controlled trial. J. Epidemiol. Community Health 58, 83–88.

Van Heuvelen, M.J., Kempen, G.I., Brouwer, W.H., De Greef, M.H., 2000. Physical fitness related to disability in older persons. Gerontology 46, 333–341.

Voorrips, L.E., Lemmink, K.A., Van Heuvelen, M.J., Bult, P., Van Staveren, W.A., 1993. The physical condition of elderly women differing in habitual physical activity. Med. Sci. Sports Exerc. 25, 1152–1157.

Vuori, I., 1995. Exercise and physical health: musculoskeletal health and functional capabilities. Res. Q. Exerc. Sport. 66, 276–285.

Wolfson, L., Whipple, R., Derby, C., Judge, J., King, M., Amerman, P., Schmidt, J., Smyers, D., 1996. Balance and strength training in older adults: intervention gains and Tai Chi maintenance. J. Am. Geriatr. Soc. 44, 498–506.

Zhang, K., Werner, P., Sun, M., Pi-Sunyer, F.X., Boozer, C.N., 2003. Measurement of human daily physical activity. Obes. Res. 11, 33–40.

J Bone Miner Res 21:S170, 2006

The Association between Vitamin D levels and Functional Capacity of Daily Living among Japanese Frail Elderly

J. Okuno[1], S. Tomura[1], H. Yanagi[1], N. Yabushita[1], T. Okura[1], K. Tanaka[1]. [1]Graduate School of Comprehensive Human Sciences, University of Tsukuba, Tsukuba, Japan.

The aim of this study was to evaluate the association between serum vitamin D levels and functional capacity of activity of daily living (ADL) among Japanese frail elderly. The study was a cross-sectional survey conducted in a town near Tsukuba city (latitude 36°north) in June 2005. Participants were community-dwelling elderly aged 65 years and over who required support or nursing care to maintain ADL. The Ethics Committee of University of Tsukuba approved the study. A face-to-face interview was conducted based on a questionnaire including score of functional capacity of ADL (Tokyo Metropolitan Institute of Gerontology; TMIG score), experiences of fall, stumbling and body sway during the past one year, walking ability, and the frequency of going outside of the home. The serum level of 25- hydroxy vitamin D_3 (25OHD), intact parathyroid hormone (iPTH) and calcium were measured in order to evaluate vitamin D status. The following tests were measured: Timed Up & Go (TUG) and a 5-meter walk for walking ability, functional reach and ankle strategy for balance, trunk flexion for flexibility, and grip strength for muscle strength. The age of 46 participants was 76.5±5.9 years (mean±SD, range: 65-90). Among the participants, 26.1% of the elderly required minimum support in ADL, and 73.9% had difficulties in standing up or walking and required moderate nursing care for ADL's, e.g., bathing. Of this population, 26.0% had joint disorders. 54.3% experienced falls, 80.4% experienced stumbling and body sway more than once during the past one year, and 47.8% were homebound. The average level of 25OHD was 63.0±14.1 nmol /L (mean±SD, range: 27.5-87.5) in this population. The 25 percentile of the concentration of 25OHD was 55.6 nmol/L, and 84.1% of the elderly had a level of 25OHD of less than 80 nmol/L. Significant negative correlations were found between 25OHD and iPTH ($r = -0.37$, $P = 0.032$) or TUG ($r= -0.35$, $P = 0.044$) adjusted by age and gender. Significant positive correlations were observed between 25OHD and calcium levels ($r = 0.36$, $P = 0.038$) or trunk flexion ($r = 0.41$, $P = 0.017$) adjusted by age and gender. The level of 25OHD was significantly lower in the elderly with difficulties in walking independently, those with functional reach < 23 cm, and those with TMIG score≦10. The ratio of 25OHD level below 55.6 nmol/L was significantly higher in the group with lower walking ability, body imbalance or being homebound. It is suggested that in the Japanese frail elderly, vitamin D deficiency is associated with inferior walking ability or body balance, and that higher vitamin D levels may be needed to prevent fall and to maintain functional capacity of ADL.

教育医学　第51巻　第4号　263～273頁（2006年6月）

在宅脳血管疾患者における転倒予防の意義と今後の可能性

新村由恵[1]，坂井智明[2]，田中喜代次[2]

Fall Prevention in Stroke Patients

Yukie SHIMURA[1], Tomoaki SAKAI[2] and Kiyoji TANAKA[2]

Ⅰ．はじめに

「高齢社会」といわれる日本では，現在もなお高齢化が進んでおり，65歳以上の人口が2560万人，高齢化率が20.0%となった[60]．それに伴い，要介護の高齢者数も，増加の一途にある[35]．我が国では，要介護高齢者が不可避的に増加することへの対策として，平成12年4月から介護保険制度を導入し，介護の充実を図ろうとしている．特に，長生きをするだけではなく，生活の質（quality of life：QoL）をより良好に維持することが重要視されており，要支援・要介護ではない生活，つまり健康で自立した生活を送ることのできる期間（健康寿命）を延ばすことをねらいとしたさまざまな試みがなされている[21,46,49,56,57]．

その一つが転倒予防である．転倒は，骨折を引き起こす危険性が高く，それが寝たきりにつながることも少なくない．そのため，転倒予防は寝たきりの1次予防策として位置づけられており，我が国では，保健事業第4次計画による健康教育事業の中で，寝たきり防止事業として転倒骨折予防教室が展開されている[34]．

我が国における高齢者の転倒率は，年間約10～20%であり，そのうち約10%が骨折に至る[64]．また，転倒により骨折などの外傷を被らなかったとしても，転倒への恐怖心から外出を控え，不活動となり，要介護を招く恐れもある[61]ことから，転倒は高齢者における要介護要因の第4位にあげられている[36]．American Geriatrics Society（2001）のガイドラインによると，欧米における65歳以上の高齢者の転倒率は35～40%と高率であり[2]，欧米諸国においても転倒は注目されている．国内外を問わず，転倒予防は今後の高齢社会における要介護者減少のための重要な課題といえよう．

Ⅱ．脳血管疾患者における転倒予防の必要性

A．脳血管疾患者とは

脳血管疾患の代表的疾患としては，局所性脳機能障害である出血性の脳出血・くも膜下出血・脳動静脈奇形に伴う頭蓋内出血と，閉

1）筑波大学大学院人間総合科学研究科
〒305-8574 茨城県つくば市天王台1-1-1
筑波大学総合研究棟D棟

2）筑波大学人間総合科学研究科
〒305-8574 茨城県つくば市天王台1-1-1
筑波大学総合研究棟D棟

1）Doctoral Program of Comprehensive Human Science, University of Tsukuba
Laboratory of Advanced Research D, 1-1-1 Tennodai, Tsukuba City, Ibaraki (305-8574)

2）Graduate School of Comprehensive Human Sciences, University of Tsukuba
Laboratory of Advanced Research D, 1-1-1 Tennodai, Tsukuba City, Ibaraki (305-8574)

塞性の脳梗塞の4つがあげられる[22]．脳血管疾患発症により伴う後遺症として，運動障害，感覚障害，失語・失行・失認といった高次脳機能障害，視力障害などの脳神経障害，意識障害など，さまざまな症状があげられ，これらの症状により脳血管疾患者は日常生活に多くの支障をきたす．その中でも運動麻痺は発症頻度が高く，リハビリテーションの対象病態として最重要視されている．

運動麻痺とは，大脳皮質運動野から筋に至る神経路や筋の障害により随意的な筋の収縮力が低下した状態をいい，障害される部位により不随症状に特徴がある．運動麻痺には，単麻痺，片麻痺，対麻痺，四肢麻痺などさまざまな麻痺症状があるが，運動麻痺で最も多くみられる症状が一側上下肢に麻痺が生じる片麻痺である[24]．大脳は左脳と右脳に分かれており，片麻痺のうち，左脳に障害が起これば右半身に麻痺が，右脳に障害が起これば左半身に麻痺が生じる．

我が国では医療技術の発展により脳血管疾患者の救命率の改善とともに，生存率が高まった[37]ことから，片麻痺等の後遺症を保有した脳血管疾患有病者数は増加している[33]．厚生労働省（2004）の報告によると，現在，脳血管疾患は要介護の要因第1位にあげられており，彼らの自立度の維持・改善に向けた施策は非常に重要である[36]．

B．脳血管疾患者の転倒率

脳血管疾患罹患の後遺症の一つである片麻痺は，その程度に個人差はあるものの，一般に日常生活動作の障害や身体機能の低下をもたらす．そのため，脳血管疾患者の転倒率は，一般に転倒率が高いとされる在宅高齢者の35～40%[2]よりもさらに高い[18,25,68]．脳血管疾患者はその回復過程から急性期，回復期，慢性期の3つに大別され[23]，入院中である急性期（脳血管疾患発症から離床までの期間）および回復期（離床から退院までの期間）と，退院後の慢性期[27]では転倒発生状況が異なるため，以下に分けて述べることにする（表1）．

B-1．急性期および回復期脳血管疾患者の転倒率

急性期および回復期の脳血管疾患者は，通常病院に入院しているため病院内での転倒が多く，転倒発生率は急性期で14%[65,66]，回復期で24～47%[18,39,41,47,69]と報告されている．これらの調査は，脳血管疾患発症後から約2～6週間と短い期間の転倒について調査しているにも拘らず，一般高齢者（65歳以上）における1年間の転倒率35～40%と比べて非常に高い[2]．

脳血管疾患者の骨折の84%が転倒を原因とする[32]ことに加え，入院中の脳血管疾患者に起こる外傷の多くが転倒を原因としている[48]ことから，脳血管疾患者のための転倒予防の必要性が指摘されている．また，本来機能回復を目的とするリハビリテーション中に転倒が多く発生することも問題視されている[13,19,42,69]．

B-2．在宅脳血管疾患者（慢性期脳血管疾患者）の転倒率

脳血管疾患者の中でも在宅脳血管疾患者が転倒する危険性は特に高いといわれている．脳血管疾患者の多くは，病院での集中的なリハビリテーションの後，退院して自宅で生活する．自宅は病院内とは異なり，脳血管疾患者にとって安全管理の行き届かない環境であることから，生活を営む上で多くの困難を伴い，転倒の危険性も高まる．Forster et al.（1995）は，脳血管疾患者の入院中から退院後にかけての転倒率の変化を検討するために，脳血管疾患者における脳血管疾患発症前から退院後6ヵ月間の転倒発生について縦断研究をおこなった[18]．脳血管疾患者の転倒率は，脳血管疾患発症前には21%であったのが，入院中には46%，退院後6ヵ月間には73%と増加の一途を示した．また，Hyndman et al.（2002）やLamb et al.（2003）は，脳血管疾患発症後，2年経過している脳血管疾患者の転倒率は1年間で48～50%[25,28]，Jorgensen et al.（2002）は脳血管疾患発症後10年以上経過している脳血管疾患者の転倒率はたった4ヵ月間で23%に至ったと報告している[30]．さらに，Chiu et al.（1992）やKanis et al.（2001）は，発症後長い期間を経ている脳血管疾患者ほど転倒および骨折を起こしやすいと報告している[8,32]．このように退院後の脳血管疾患者の転倒率は入院中と比べて高率であり，脳血管疾患

表1　脳血管疾患者および一般高齢者の転倒率

	脳血管疾患者			一般在宅高齢者
	急性期	回復期	慢性期（在宅）	
報告者（年）	Tutuarima et al. (1993) Tutuarima et al. (1997)	Forster et al. (1995) Langhorne et al. (2000) Mayo et al. (1990) Nyberg et al. (1995) Vlahov et al. (1990)	Forster et al. (1995) Hyndman et al. (2002) Lamb et al. (2003) Jorgensen et al. (2002)	American Geriatrics Society. (2001)
期間	7週間	2～6週間	4ヵ月～12ヵ月間	12ヵ月間
転倒率	約14%	24～47%	48～73%	35～40%

者の要介護化を予防するためには，入院中だけではなく退院後の転倒予防策の充実が必要不可欠である．

C．脳血管疾患者の骨密度

骨密度の低下は骨折の危険因子として問題視されている[9,11,40]．一般高齢者における骨密度の低下は，除脂肪量の低下および体脂肪量の増加といった体組成の変化と関係があると報告されている[3,44,63]．しかしながら，脳血管疾患者の骨密度の低下は体組成の変化と関係がなく[54]，長期にわたる不活動および寝たきりにより起こる[7,71]．Ramnemark et al. (1999)，Del Puente et al. (1996) は，脳血管疾患者は麻痺側における骨密度の低下が著しく，麻痺側における大腿骨の骨密度は，非麻痺側と比べて4～7.5%低いと報告している[12,53]．さらに，脳血管疾患発症後の骨密度の縦断的な変化をみた研究報告を紹介する．Hamdy et al. (1995) は，急性期脳血管疾患者を対象にその後6ヵ月間の骨密度の変化を調査し，上下肢ともに脳血管疾患発症後1ヵ月間で大きく低下し，4ヵ月以降に有意な低下はみられないと報告している[22]．Ramnemark et al. (1999) は脳血管疾患発症1ヵ月後から12ヵ月間にわたる骨密度の変化を調査し，脳血管疾患発症から12ヵ月後にかけて骨密度は減少し続けると報告しており[53]，どちらもある一定期間が過ぎれば骨密度は減少しないと報告している．また麻痺側の骨密度の低下は，下肢よりも上肢で著しいと示している[22,53]．

これらの研究は骨密度の変化を縦断的に調査しているが，障害のレベルによる違いまでは調査していない．脳血管疾患者における障害レベルは幅広く，そのため活動レベルもさまざまである．不活動は脳血管疾患者の骨密度低下の危険因子であることから，次に障害レベルや活動レベルの違いによる骨密度の低下の相違について紹介する．Jorgensen et al. (2000) は，脳血管疾患者を車椅子使用の者，脳血管疾患発症後2ヵ月以内に歩行練習を開始した者，自立歩行が可能な者の3つの歩行レベルで分類し，それぞれにおける下肢の骨密度の変化を調査した[31]．その結果，脳血管疾患発症初期の下肢への荷重の欠如が，麻痺側の下肢における著しい骨密度低下の要因となっており，発症後2ヵ月以内に歩行練習を開始することは，その後の骨密度の低下を緩和すると報告している．さらにJorgensen et al. (2001) は，下肢よりも骨密度の低下が著しい上肢[21,27,53]においても同様に調査し，麻痺側における上肢の障害が大きい者ほど上腕骨の骨密度の低下が著しいと報告している[29]．

以上のことから，脳血管疾患者の骨密度の低下は，発症後の障害レベルや，急性期から回復期にかけての活動レベルの影響を大きく受け，その後はほとんど変化しないことが示唆された．脳血管疾患者の骨折による要介護化を防ぐためには，急性期や回復期に活動レベルを高めるとともに，慢性期に転倒を防ぐことが重要である．

D．脳血管疾患者の骨折

脳血管疾患者の骨折率は，脳血管疾患を有さない者の約4倍と高率である[41,45,57]．中でも，大腿骨頸部骨折の発生率は全骨折数の45～52%と最も高く[32,52]，その62.5%～83.3%は麻痺側で多く起こる[6,50,51,52]．骨折の主な原因としては，麻痺側の著しい機能低下による麻痺側への転倒，および前述した麻痺側における

骨粗鬆症の進行，つまり骨密度の低下があげられており[6,45]（図1）．これらを予防することが骨折を未然に防ぐ上で重要である．また，骨折がその後の生活に及ぼす影響を調査するための縦断研究もおこなわれている．Ramnemark et al.（2000）は，片麻痺を有する骨折患者と他の骨折患者における骨折後の自宅への退院状況および骨折後の死亡率について調査した結果，脳血管疾患を伴わない患者に比べて脳血管疾患者の方が機能低下が著しく，骨折後の死亡率が有意に高まり，5年後には脳血管疾患者の死亡率は80.3%にまで達したと報告している[51]．このことからも，脳血管疾患者の骨折を予防することの意義が伺える．

脳血管疾患発症後どの期間に骨折する危険性が高いかについては，いまだ一致した見解が得られていない．Ramnemark et al.（2000）は，脳血管疾患発症後5年目の慢性期に多く起こると報告している[51]一方で，Kanis et al.（2001）は脳血管疾患発症後1年間に多く起こると報告している[32]．このような調査においては，長期にわたる縦断研究が必要であるが，その数は少なく，今後進めていくべき重要な課題である．

Ⅲ．急性期・回復期脳血管疾患者と在宅脳血管疾患者の転倒状況の違い

先で述べたように，在宅脳血管疾患者における転倒率は入院中と比べて高率であり，その背景には生活環境の違いがある．医師や看護師により安全管理のなされた病院と比べ，自宅という管理の行き届かない環境が転倒の危険性を高めている．さらに，生活環境の違いが影響し，両者の転倒が起こる状況も異なる．両者の転倒原因に大きな違いはないが，転倒場所や転倒時の動作はさまざまであり，在宅脳血管疾患者の活動範囲の広さが転倒に影響していることが伺える．

転倒状況は，転倒予防プログラムを考案する上で重要な資料である．表2に，急性期・回復期脳血管疾患者と在宅脳血管疾患者における転倒状況を示した．

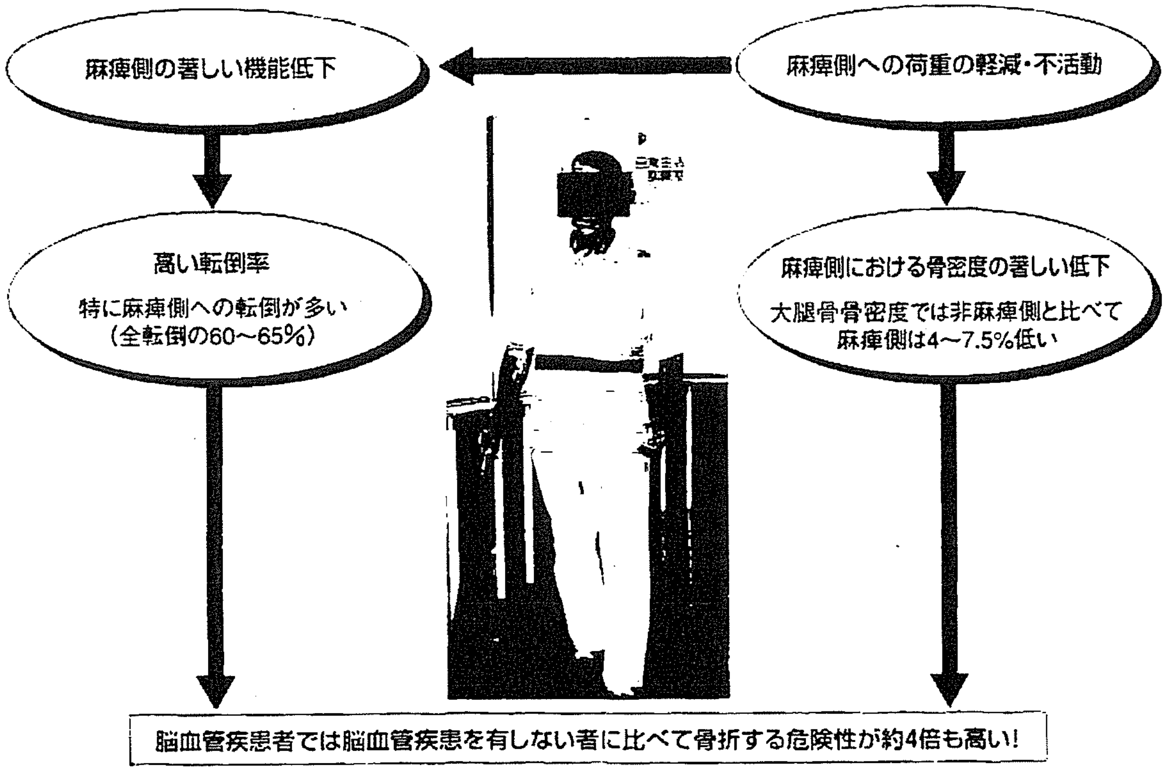

図1　脳血管疾患者の骨折の主な原因

A．転倒場所

急性期・回復期脳血管疾患者の転倒は多くが病院内で起こっており．51～58%は自分の病室で起こっており，次いで食堂，風呂やトイレで多く生じていた[47,66].

一方，在宅脳血管疾患者の転倒の80%は自宅で起こっており[25]，庭，寝室．居間．廊下と様々な場所で生じており[25,59]，急性期・回復期と比べて活動範囲の広さが伺える．屋内外での転倒発生頻度の比較では，Hyndman et al. (2002)は屋外で転倒が多く起こる[25]，Jørgensen et al. (2002)は屋内外で差がない[30]，新村ら(2005) は屋内で多く起こると報告しており[59]，一致した見解は得られていない．

B．転倒時間

急性期・回復期脳血管疾患者の転倒は，1日の中でも活動量の多い日中に多く[47,62,65]，同様に在宅脳血管疾患者においても転倒の70～80%が日中に起こっている[25,30,59].

C．転倒時の動作

急性期・回復期脳血管疾患者の転倒は，横方向などへの移動時，車椅子から他の場所への移乗時，介助無しの歩行時に多く起こる[47,65].

一方，在宅脳血管疾患者の転倒は，歩行時，横への移動時，方向転換時，椅子や床からの起立および着席時など．幅広い活動時に多く起こることが報告されており，中でも歩行時に最も多く起こっている[18,25,59].

D．転倒原因

急性期・回復期脳血管疾患者の転倒原因としては，バランス障害、姿勢維持の障害，足の不動，認知障害，麻痺による左右の動作障害．半側空間無視[47,48]，起立時のふらつき[55]，反応時間の遅れ[5,42]，椅子からの起立時および着席時の重心動揺の増大[5] といった、脳血管疾患者自身が持つ内的因子の影響が大きい．

在宅脳血管疾患者においては，脳血管疾患者特有の動作であるバランスの消失、足の引きずり[18,25]，脚の不動．つまずき[39]．起立および着席時の重心動揺の増大、体重移動の遅延．移動時に発揮する脚筋力の低下，非麻痺側への荷重の増加[5] と様々な原因があげられているが，これらは全て脳血管疾患の後遺症である運動障害によるものである．これら運動障害は脳血管疾患による後遺症の一つであり，脳血管疾患者の60～78%が有している[20]．また，鬱症状[30,65] や、集中力および判断力の低下[25] などの精神症状も転倒原因としてあげられている．Lamb et al. (2003) は，1回のみの転倒はバランスの消失が原因であり．複数回におよぶ転倒は移動障害が原因であると報告している[34]．このように，急性期・回復期脳血管疾患者と在宅脳血管疾患者の転倒は，共に脳血管疾患の後遺症である運動障害が主な原因となっている．

表2. 急性期・回復期片麻痺者と在宅片麻痺者における転倒状況

	急性期・回復期片麻痺者		在宅片麻痺者	
転倒場所	病院内：51～58%は自分の病室．食堂．浴室．トイレなど．		80%は自宅．庭．寝室．居間．廊下など．	幅広い活動時に起こる
転倒時の動作	車椅子から他の場所への移乗時 横方向への移動時 介助なしの歩行時		歩行時 椅子や床からの起立および着席時 段差の昇降時 階段の昇降時 方向転換時 横への移動時	
転倒時間	活動量の多い日中		活動量の多い日中	
転倒原因	バランス障害 足の不動 起立および着席時の重心動揺の増大 姿勢維持の障害 麻痺による動作障害 起立時のふらつき 反応時間の遅れ 半側空間無視 認知障害	運動障害が主な原因	バランス障害 足の不動や引きずり つまずき 起立および着席時の重心動揺の増大 非麻痺側への荷重の増加 体重移動の遅延 非麻痺側への荷重の増加 移動時に発揮する脚筋力の低下 自立度 鬱症状 集中力および判断力の低下	運動障害が主な原因

表3　転倒時動作と転倒原因との連関（新村ら，2005）

	Loss of balance	Foot getting stuck	Legs giving way	Dizziness	Blackout	Misjudgment	Tripping	Slipping	Bumping	Stumbling
Sitting (on a chair) to standing	*					*				
Sitting to standing on the floor	*									*
Bending								*		
Walking on a flat floor		*					*			
Going up or down one step									*	
Going up or down stairs										
Placing or retrieving overhead objects	*									
Turning										

The result of residual analysis. $^{*}P< 0.05$

在宅では急性期や回復期のように安全な環境作りは難しく，さまざまな状況で転倒が誘発される．転倒状況および運動障害を考慮し，安全に活動できるよう支援することが彼らの転倒を予防する上で重要である．

E．転倒時動作と転倒原因の連関

多くの先行研究では上記のように，転倒場所・転倒時刻・転倒時の動作や転倒原因と，状況に関する各項目を調査してきた．しかし，転倒予防プログラムを作成するための基礎資料とするのであれば，各項目の関係を検討する必要がある．新村ら（2005）は，転倒時の動作にはそれぞれ特徴があるため，各動作により転倒原因も異なるのではないかと考え，転倒時の動作と転倒原因との連関について検討し，転倒時の各動作には連関する転倒原因が存在すると報告している[3]（表3）．より多くの脳血管疾患者の転倒を予防するためには，脳血管疾患者一人ひとりの転倒しやすい動作を把握するとともに，その動作と連関の強い転倒原因の解決を目指した，オーダーメイド予防プログラムの開発が必要である．

Ⅳ．脳血管疾患者の転倒予防プログラムの現状

急性期・回復期脳血管疾患者と在宅脳血管疾患者の両者の転倒原因として脳血管疾患の後遺症である運動障害があげられていることから，脳血管疾患者のための転倒予防をねらいとした運動プログラムの必要性が伺える．

Cheng et al.（1998）は，椅子からの起立および着席動作が脳血管疾患者の転倒と関係があることを報告しており[5]，その結果をもとに急性期脳血管疾患者の転倒予防を目的とした運動プログラムを提案している[7]．入院中の急性期脳血管疾患者を対象に，重心動揺記録システムを搭載したバイオフィードバックトレーナーというマシンを用い，姿勢安定トレーニングを30分間おこない，15分間の休憩の後，指示した音にあわせて椅子からの起立および着席運動を20分間おこなうというものである．プログラムは週に5日，3週間指導した．その結果，重心動揺が減少するとともに，椅子からの起立および着席動作に改善が認められたと報告している．介入後6ヵ月間の転倒率をみると，運動プログラム介入群（16.7%）は，通常のリハビリテーションのみをおこなったコントロール群（41.7%）と比べ，有意に低かったと報告している．しかしながら，両群における介入前の転倒率が調査されていないため，対象者らの転倒率の差が，運動プログラム介入による効果なのかは明確ではない．さらにCheng et al.（2004）は，Balance Masterという評価およびトレーニング機器を用いたvisual feedback rhythmic weight-shift trainingを急性期片麻痺者のリハビリテーションに組み込むことで動的バランスが改善し，6ヵ月後にもその効果は維持され，有意ではないが転倒率も減少すると報告している[6]．なお，プログラムは1回20分とし，週に5日を3週間指導した．

しかしながら，脳血管疾患者の転倒予防を目的とした運動プログラムに関する研究は非常に少ない．さらに上記のプログラムは急性期脳血管疾患者を対象に病院のリハビリテーションの一環としておこなったものであり，より転倒の危険性の高い在宅片麻痺者のためのプログラムは見当たらない．このように脳血管疾患者，特に在宅脳血管疾患者の転倒予防プログラムの提供は，一般高齢者と比べて遅れている．転倒率の高さ，および在宅脳血管疾患者数の増加を考慮すると，彼らへの転倒予防の必要性は高く，早急なプログラムの検討および提案が要求される．

V．在宅脳血管疾患者に向けた運動プログラムの効果の可能性

在宅脳血管疾患者の転倒予防をねらいとした運動プログラムは非常に数が少ないが，身体機能の維持・改善を目的とした運動プログラムはおこなわれている．これまで，リハビリテーションによる回復は発症後3ヵ月後までが最も著しく[28]，移動能力の回復は発症後3～6ヵ月で終了すると報告されており[15,30]，急性期脳血管疾患者を対象とした院内リハビリテーションが中心におこなわれてきた．しかしながら，近年では入院中の急性期脳血管疾患者のみならず，発症後6ヵ月以上経過した脳血管疾患者にもリハビリテーションの効果が得られることが明らかになり，在宅脳血管疾患者を対象としたリハビリテーションとして運動プログラムが提供されており，様々な運動障害改善への効果が報告されている．これら運動プログラムの効果と，表2で示した転倒原因である運動障害とを照らし合わせて，運動プログラムによる転倒予防の可能性を検討する．

A．施設における運動プログラム

Engardt et al.（1995）は，脳血管疾患発症後2年経つ脳血管疾患者を膝伸展運動群，膝屈曲運動群の2群に分け，筋力トレーニングを指導したところ，両群とも麻痺側における膝伸展筋および膝屈曲筋に改善が認められ，膝伸展群においては，椅子からの起立時に左右それぞれの足にかかる体重分布の差も有意に減少したと報告している[17]．Sharp et al.（1997）は，脳血管疾患発症後6ヵ月以上経つ脳血管疾患者を対象に，麻痺側における下肢のアイソキネティックトレーニングを指導し，膝伸展筋および膝屈曲筋における筋力の向上を認めた[38]．さらに歩行能力を低下させるといわれている痙性[10]の増加を防ぐことができ，歩行速度が速くなったという．Weiss et al.（2000）は，慢性期脳血管疾患者に膝および股関節伸展による高強度の筋力トレーニングを12週間指導し，その効果を縦断的に検討したところ，下肢筋力は麻痺側で68%，非麻痺側で48%改善し[31]，その結果，椅子からの起立時間，静的および動的バランス能力が改善したと報告している．またAda et al.（2003）は，歩行トレーニングを4週間指導した後に，3ヵ月間のフォローアップ期間を設けた結果，トレーニング終了時に歩行能力の改善が認められ，その改善は3ヵ月後も維持できることを明らかにしている[1]．Eng et al.（2003）はバランス能力，移動能力，筋力，巧緻能力の改善を目的とした複数の運動から成るトレーニングをおこなった結果，バランス，歩行速度，持久力，階段昇降時における歩行速度に改善が認められ，その改善は1ヵ月後持続可能であることを報告している[16]．

B．自宅における運動プログラム

上記の在宅脳血管疾患者のための運動プログラムは，病院やリハビリテーションセンター，コミュニティセンターなどの施設で提供されたものであるが，脳血管疾患者は毎日施設に赴くことは困難であり，また何らかの理由により施設にまったく赴くことができない者もいる．そこで，近年自宅における運動プログラムが推奨されている．Duncan et al.（1998）は，在宅脳血管疾患者を対象に，PNFもしくはセラバンドを用いた上下肢の筋力ト