Table 3 Relationship between length of stay (LOS) and items from the basic activities of daily living (BADL)

Item	LOS		*P* value
	≤ 27 days	≥ 28 days	
Fecal incontinence			
Independent	50 (50.0%)	50 (50.0%)	0.04*
Dependent	4 (22.2%)	14 (77.8%)	
Urinary incontinence			
Independent	48 (52.7%)	43 (47.3%)	0.005
Dependent	6 (22.2%)	21 (77.8%)	
Grooming			
Independent	50 (46.7%)	57 (53.3%)	NS*
Dependent	4 (36.4%)	7 (63.6%)	
Toileting			
Independent	50 (52.1%)	46 (47.9%)	0.004*
Dependent	4 (18.2%)	18 (81.8%)	
Feeding			
Independent	52 (49.1%)	54 (50.9%)	0.04*
Dependent	2 (16.7%)	10 (83.3%)	
Transfer			
Independent	48 (52.7%)	43 (47.3%)	0.002
Dependent	5 (19.2%)	21 (80.8%)	
Walking			
Independent	46 (52.3%)	42 (47.7%)	0.02
Dependent	8 (26.7%)	22 (73.3%)	
Dressing			
Independent	50 (53.8%)	43 (46.2%)	< 0.001*
Dependent	4 (16.0%)	21 (84.0%)	
Stairs			
Independent	40 (55.6%)	32 (44.4%)	0.008
Dependent	14 (30.4%)	32 (69.6%)	
Bathing			
Independent	47 (54.7%)	39 (45.3%)	< 0.001
Dependent	7 (21.9%)	25 (78.1%)	

*Fisher's exact probability test

medication was significant. In model 3, items of calculation and copying a design, which had *P* values less than 0.10, were considered, and only calculation was significant. Model 4, in which every item that had a *P* value less than 0.10 was considered, showed that dressing and medication were significant. In model 5, items of physical function, social status and the total scores of both BADL and IADL, and MMSE were considered, and the total score of the BADL (Barthel index) was significant.

Discussion

The present study investigated the factors associated with long LOS. Single-variant analysis showed that the factors significantly associated with a LOS of more than 28 days were the total scores of both the BADL and IADL, the items of vision, economic status, and group behaviour.

Several studies have reported an association of LOS with ADL,[10–15] but not which items of the ADL are important for determining LOS. In the current study, Chi-squared analysis showed that all BADL items, except grooming, had a significant association with longer LOS. In multiple logistic analysis model 5, the total score of the ADL had the highest odds ratio, and within the ADL items (model 1) dressing was the factor most strongly associated with LOS. In model 4, in which all the items were considered, the item that had the strongest association was dressing. These results indicate that in the current study dependence of dressing had the most significant association with longer

Table 4 Relationship between length of stay (LOS) and instrumental activities of daily living (IADL)

Item	LOS		*P* value
	≤ 27 days	≥ 28 days	
Telephone			
Independent	52 (47.3%)	58 (52.7%)	NS*
Dependent	2 (25.0%)	6 (75.0%)	
Shopping			
Independent	42 (54.5%)	35 (45.5%)	$P = 0.009$
Dependent	12 (29.3%)	29 (70.7%)	
Preparing meals			
Independent	27 (60.0%)	18 (40.0%)	$P = 0.02$
Dependent	27 (37.0%)	46 (63.0%)	
Housework			
Independent	46 (52.9%)	41 (47.1%)	$P = 0.009$
Dependent	8 (25.8%)	23 (74.2%)	
Laundry			
Independent	42 (56.8%)	32 (43.2%)	$P = 0.002$
Dependent	12 (27.3%)	32 (72.7%)	
Travel			
Independent	52 (48.6%)	55 (51.4%)	$P = 0.06$*
Dependent	2 (18.2%)	9 (81.8%)	
Medication			
Independent	44 (56.4%)	34 (43.6%)	$P < 0.001$
Dependent	10 (25.0%)	30 (75.0%)	
Money			
Independent	51 (50.0%)	51 (50.0%)	$P = 0.03$*
Dependent	3 (18.8%)	13 (81.3%)	

*Fisher's exact probability test

LOS; however, the reason was not clear. Independence with dressing requires physical function as well as some aspects of judgment and therefore, the item of 'dressing' may represent a combination of several aspects of physical and mental function. Interestingly, intervention trials have shown an improvement in independent dressing[16,17] and a GEM approach stressing capability with dressing should reduce LOS.

Chi-squared analysis showed that all items in the IADL, except telephone use and travel, were significantly associated with longer LOS. Both multilogistic analysis model 2, in which IADL items were analysed, and analysis model 4 showed that needing assistance with medication significantly increased the chance of having longer LOS. Our previous study showed that patients who need medication assistance had significantly lower scores in ADL, IADL, and MMSE.[18] Therefore, this item could also represent a combination of aspects. Issac *et al.* demonstrated that cognitive function strongly affected medication compliance in elderly patients.[19]

Age and living status (living alone or not) were not significant factors. Epstein *et al.* showed that patients of low socioeconomic status, including lower income, had longer hospital stays[20] and in the current study economic status was a significant factor in single variant analysis; however, multiple logistic analysis failed to show statistical significance. The current subjects were relatively wealthy and only 5% needed monetary assistance from relatives, whereas in the Epstein study 14% of the subjects had annual incomes less than US$5000, which would affect the results of statistical analysis.

Incalzi *et al.* showed that extended hospital stay was significantly and independently predicted by polypharmacy and comorbidity, demonstrating that patients who were prescribed six or more medications and three or more diagnoses had significantly longer LOS.[11] In the current study, patients with six or more medications had longer LOS (43.9 *vs* 36.1 days), although it was not statistically significant, whereas the number of diseases did not have an impact on LOS.

The 4score, an index developed by Glass *et al.*,[21] defines four factors associated with longer LOS: (1) Is the patient 80 years old or more? (2) Will the patient have to live somewhere new at discharge? (3) Is there

Table 5 Relationship between length of stay (LOS) and items from the mini-mental state examination (MMSE)

Item	LOS		*P* value
	≤ 27 days	≥ 28 days	
Orientation (time)			
Fully	38 (51.4%)	36 (48.6%)	NS
Not fully	16 (36.4%)	28 (63.6%)	
Orientation (place)			
Fully	40 (48.2%)	43 (51.8%)	NS
Not fully	14 (40.0%)	21 (60.0%)	
Registration			
Fully	54 (46.2%)	63 (53.8%)	NS*
Not fully	0 (0.0%)	1 (100.0%)	
Calculation			
Fully	29 (58.0%)	21 (42.0%)	$P = 0.02$
Not fully	25 (36.8%)	43 (63.2%)	
Recall			
Fully	33 (52.4%)	30 (47.6%)	NS
Not fully	21 (38.2%)	34 (61.8%)	
Language			
Fully	53 (45.7%)	63 (54.3%)	NS*
Not fully	1 (50.0%)	1 (50.0%)	
Repeat			
Fully	50 (45.0%)	61 (55.0%)	NS*
Not fully	4 (57.1%)	3 (42.9%)	
Three-stage command			
Fully	53 (46.1%)	62 (53.9%)	NS*
Not fully	1 (33.3%)	2 (66.7%)	
Read and obey			
Fully	53 (46.5%)	61 (53.5%)	NS*
Not fully	1 (25.0%)	3 (75.0%)	
Write a sentence			
Fully	51 (47.2%)	57 (52.8%)	NS*
Not fully	3 (30.0%)	7 (70.0%)	
Copy a design			
Fully	50 (49.5%)	51 (50.5%)	$P = 0.07$*
Not fully	4 (23.5%)	13 (76.5%)	

*Fisher's exact probability test

any disorientation? (4) If so, is the disorientation chronic? Two or more positive answers to these questions on admission increases the length of social stay in hospital. In the current study, neither the total score of the MMSE nor the item of 'orientation' was significantly associated with longer LOS. Age was not a significant factor, either. The disagreement could be explained by the different settings. The Glass study was done in an acute medical care ward, and in the current study the setting was a mixture of acute care and rehabilitation unit. Therefore, the factors associated with longer LOS may depend on the type of facility.

The current study was conducted in a geriatric ward in a university hospital and the patients had several particular characteristics compared with other hospitals in Japan. They were relatively wealthy[18] and many had a family member to live with (95 of 118 patients). Further analysis should be performed to confirm that the factors identified in the current study are significant in different settings.

In conclusion, in Japanese geriatric wards, dependence with the BADL, specifically dressing and taking medication, were the factors significantly associated with a LOS of more than 28 days.

Table 6 Multilogistic analysis of factors associated with longer length of stay (LOS)

	Model 1	Model 2	Model 3	Model 4	Model 5
No. of patients	118	118	118	118	118
Vision				–	–
Economic status				–	–
Group behavior				–	–
Total BADL score					5.1 (1.8 : 14.7)**
Fecal incontinence	–			–	
Urinary incontinence	–			–	
Toileting	–			–	
Transfer	–			–	
Walking	–			–	
Dressing	6.1 (1.9 : 19.2)**			4.1 (1.2 : 13.6)*	
Stairs	–			–	
Bathing	–			–	
Total IADL score					–
Shopping		–		–	
Preparing meal		–		–	
Housework		–		–	
Laundry		2.5 (1.0 : 5.9)*			
Travel		–		–	
Medication		2.8 (1.1 : 6.9)*		2.6 (1.1 : 6.5)*	
Money		–		–	
Total MMSE score					
Calculation			2.4 (1.1 : 5.0)*	–	
Copy a design			–	–	

In each model the variables were selected by step-wise method.
The variables that were analysed in each model, but not selected, are expressed by –.
The selected variables are expressed as odds ratio (95% confidence interval) and P value (*$P < 0.05$, **$P < 0.01$).

References

1 Ozawa T. Comprehensive geriatric assessment. *Jpn J Geriatr* 1998; **35**: 1–9.
2 Rubenstein LZ, Stuck AE, Siu AL, Wieland D. Impacts of geriatric evaluation and management program on defined outcomes: Overview of the evidence. *J Am Geriatr Soc* 1991; **9**: 8S–16S.
3 Stuck AE, Sie AL, Wieland GD, Adams J, Rubenstein LZ. Comprehensive geriatric assessment: a meta-analysis of controlled trials. *Lancet* 1993; **342**: 1032–1036.
4 Ledesert B, Lombrail P, Yeni P, Carbon C, Brodin M. The impact of a comprehensive multi-dimensional geriatric assessment programme on duration of stay in a French acute medical ward. *Age Aging* 1994; **23**: 223–227.
5 Collard AF, Bachman SS, Beatrice DF. Acute care delivery for the geriatric patient: an innovative approach. *Qual Rev Bull* 1985, 180–186.
6 Mahoney FI, Barthel DW. Functional evaluation: the Barthel index. *Md State Med J* 1965; **14**: 61–65.
7 Lawton MP, Moss M, Fulcomer M, Kleban MH. A research and service oriented multilevel assessment instrument. *J Gerontol* 1982; **37**: 91–99.
8 Folstein MF, Folstein SE, McHugh PR. 'Mini-Mental State': a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975; **12**: 189–198.
9 Yesavage JA. The use of self-rating depression scales in the elderly. In: Poon LW, ed. *Clinical Memory Assessment of Older Adults*. Washington DC: American Psychological Association, 1986; 213–217.
10 Rockwood K. Delays in the discharge of elderly patients. *J Clin Epidemiol* 1990; **43**: 971–975.
11 Incalzi RA, Gemma A, Capparella O *et al.* Predicting mortality and length of stay of geriatric patients in an acute care general hospital. *J Gerontol* 1992; **47**: M35–M39.
12 Reiley P, Howard E. Predicting hospital length of stay in elderly patients with congestive heart failure. *Nurs Econ* 1995; **13**: 210–216.
13 Subramanian C, Gray LC, Farish S. Predictors of length of stay in a geriatric assessment and rehabilitation unit. *Aust Health Rev* 1995; **18**: 56–68.
14 Bertozzi B, Barbisoni P, Franzoni S, Rozzini R, Frisoni GB, Trabucchi M. Factors related to length of stay in a geriatric evaluation and rehabilitation unit. *Aging Clin Exp Res* 1996; **8**: 170–175.
15 Franchignoni F, Tesio L, Martino MT, Benevolo E, Castagna M. Length of stay of stroke rehabilitation inpatients: prediction through the functional independence measure. *Ann Ist Super Sanita* 1998; **4**: 463–467.
16 Applegate WB, Akins D, Vander Z, Thoni K, Baker MG. A geriatric rehabilitation and assessment unit in a community hospital. *J Am Geriatr Soc* 1983; **31**: 206–210.
17 Beck C, Heacock P, Mercer SO, Walls RC, Rapp CG, Vogelpohl TS. Improving dressing behavior in cognitively

impaired nursing home residents. *Nurs Res* 1997; **46**: 126–132.
18 Kuzuya M, Endo H, Umegaki H *et al.* Factors influencing noncompliance with medication regimens in the elderly. *Jpn J Geriatr* 2000; **37**: 363–370.
19 Issac LM, Robyn M, Tamblyn RN, the McGill-Calgary Drug Research Team. Compliance and cognitive function: a methodological approach to measuring unintentional errors in medication compliance in the elderly. *Gerontologist* 1993; **33**: 772–781.
20 Epstein AM, Stern RS, Tognetti J *et al.* The association of patients' socioeconomic characteristics with the length of hospital stay and hospital charges within diagnosis-related groups. *N Engl J Med* 1988; **318**: 1579–1585.
21 Glass RI, Mulvihill MN, Smith H, Peto R, Bucheister D, Stoll B. The 4score: An index for predicting a patient's non-medical hospital stay. *Am J Public Health* 1977; **67**: 751–755.

3. Freeman JT. Nascher: Excerpts from his life, letters, and works. Gerontologist 1961;1:17–26.
4. Nascher IL. Geriatrics. N Y Med J 1909;90:358–359.

ATORVASTATIN, 3-HYDROXY-3-METHYLGLUTARYL COENZYME A REDUCTASE INHIBITOR, REDUCES BONE RESORPTION IN THE ELDERLY

To the Editor: The 3-hydroxy-3-methylglutaryl coenzyme A reductase inhibitors known as statins are potent inhibitors of cholesterol biosynthesis. In addition to the effect of statins on cholesterol lowering, much attention has been focused on the role of statins in bone metabolism.[1,2] A number of case-control studies regarding the relationship between the use of statins and the incidence of fracture have been reported,[3–6] but there have been no consistent results showing the effect of statins on the reduction of fracture in sampled populations. In addition, only limited data are available regarding the influence of statins on bone metabolism and bone mineral density (BMD) in humans.[7–10] We performed a prospective study in elderly subjects to examine the effect of atorvastatin on bone metabolism by measuring serum levels of bone-specific alkaline phosphatase activity (BALP) as a marker for bone formation and urine cross-linked N-telopeptides of type I collagen (NTx)/creatinine (Cr) ratio as a marker for bone resorption, together with measuring BMD.

Sixteen elderly patients with hypercholesterolemia (three men, 13 women, mean age ± standard deviation = 75.3 ± 6.3), who had not received statins, and 27 age-matched control subjects without hypercholesterolemia (nine men, 28 women; mean age = 71.8 ± 6.5) were recruited from the geriatric outpatient clinic of a university hospital. Blood and urine were sampled at three time points (before and 3 months and 6 months after the commencement of treatment with atorvastatin (or follow-up for control subjects)) for the analyses of serum lipid profile, BALP levels, and urine NTx/Cr ratio. BMDs of the lumber spine (L1–L4), right femoral neck, total hip, and right forearm were measured using dual-energy x-ray absorptiometry using a Hologic QDR-4500 A (Waltham, MA) at three time points (baseline, 6 months, and 12 months after the commencement of treatment with atorvastatin (or follow-up for control subjects)). The percentage change in BMD per year from baseline was calculated. All participants provided written informed consent to participate in the study. Subjects who had received hormone-replacement therapy or received bisphosphonate, calcitonin, anticonvulsant drug, or thyroid hormone were excluded from the study. Hypercholesterolemic patients received atorvastatin 10 mg per day. Other medications were not changed during the follow-up period (12 months).

The two groups were matched for age, sex, body mass index, and serum BALP. The NTx/Cr ratio in urine was lower in the control group, and the serum total cholesterol and low-density lipoprotein cholesterol (LDL-C) levels were higher in the atorvastatin group (Table 1). No significant difference in BMD was observed between the control and atorvastatin groups. The atorvastatin group had a significant decrease in serum total cholesterol and LDL-C levels at 3 and 6 months (Table 1), but no significant change in triglyceride or high-density lipoprotein cholesterol levels in the atorvastatin group or of all serum lipid levels in the control group were observed during follow-up. No statistically significant change in serum concentration of BALP was observed during follow-up in either group (Table 1), but the urine NTx/Cr ratio decreased significantly in the atorvastatin group at 3 and 6 months. The decreased NTx/Cr ratio was not correlated with the change in serum total and LDL-C levels after atorvastatin

Table 1. Changes in Serum Lipid Levels and Bone Makers in Control and Atorvastatin Groups

	Control Group			Atorvastatin Group		
	Baseline	3 Months (% Change)	6 Months (% Change)	Baseline	3 Months (% Change)	6 Months (% Change)
	Mean ± Standard Deviation					
Total cholesterol, mg/dL	202.9 ± 31.1	203.3 ± 27.5 (1.3 ± 9.3)	208.0 ± 34.1 (2.8 ± 14.5)	263.9 ± 33.9‖	192.5 ± 28.6 † (–27.6 ± 13.2)‖	188.6 ± 34.5 † (–28.3 ± 14.9)‖
Low-density lipoprotein cholesterol, mg/dL	124.5 ± 31.7	121.1 ± 31.2 (4.7 ± 14.3)	125.5 ± 33.1 (4.5 ± 23.8)	177.4 ± 26.9‖	108.1 ± 23.4† (–39.6 ± 18.8)‖	108.9 ± 30.5† (–37.7 ± 22.3)‖
Bone-specific alkaline phosphatase, U/L	25.1 ± 8.2	22.6 ± 7.1 (–0.7 ± 12.4)	23.4 ± 9.0 (–0.6 ± 22.7)	29.3 ± 9.8	31.1 ± 11.6 (3.1 ± 17.0)	27.9 ± 12.0 (–6.8 ± 18.3)
Cross-linked N-telopeptides of type I collagen, nmol BCE/mmol creatinine	44.9 ± 15.8	47.4 ± 12.1 (12.6 ± 46.3)	49.0 ± 15.5 (9.7 ± 25.3)	63.0 ± 19.8§	56.4 ± 26.3* (–22.2 ± 13.6)‡	52.5 ± 17.8† (–20.3 ± 18.9)‖

Note: % change indicates percentage change from baseline values.
*$P < .01$.
†$P < .001$ versus baseline.
‡$P < .05$.
§$P < .01$.
‖$P < .001$ versus control group.
BCE = bone collagen equivalent.

treatment. There was no significant difference of percentage change in BMD per year between the control and atorvastatin groups.

In the present study, we observed that atorvastatin decreased NTX/Cr in hypercholesterolemic elderly subjects. To our knowledge, this is the first prospective study demonstrating that statin treatment inhibits bone resorption in humans, but it is questionable whether the observed effect of atorvastatin is common to all the statins. Serum cholesterol level appears not to regulate atorvastatin-induced NTx/Cr ratio reduction, because there was no correlation between the reduction in NTx/Cr ratio and the degree of serum total cholesterol and LDL-cholesterol reduction by atorvastatin treatment. We could not demonstrate that atorvastatin increases bone formation by evaluating serum BALP levels. From these findings, we conclude that atorvastatin influences bone metabolism through inhibiting bone resorption rather than stimulating bone formation in hypercholesterolemic elderly subjects. In the present study, we observed that 1-year treatment with atorvastatin had no effect on BMD changes compared with that of the control group, who were not receiving atorvastatin treatment, despite substantial reduction of bone resorption, which was confirmed by a 20% decrease in bone resorption marker, NTx/Cr. The observed effect on bone resorption may not be sufficient to affect BMD for a short period of observation. Thus, a question still remains whether statins would emerge as a treatment in elderly patients at risk for fracture by manipulating bone metabolism. Large-scale, randomized, controlled, prospective studies for longer periods of observation are necessary to answer the question.

Masafumi Kuzuya, MD
Yusuke Suzuki, MD
Toshinobu Asai, MD
Teruhiko Koike, MD
Shigeru Kanda, MD
Akira Nakamura, MD
Shosuke Satake, MD
Hiroyuki Umegaki, MD
Akihisa Iguchi, MD
Department of Geriatrics
Nagoya University Graduate School of Medicine
Nagoya, Japan

REFERENCES

1. Mundy G, Garrett R, Harris S et al. Stimulation of bone formation in vitro and in rodents by statins. Science 1999;286:1946–1949.
2. Coons JC. Hydroxymethylglutaryl-coenzyme A reductase inhibits in osteoporosis management. Ann Pharmacother 2002;36:326–330.
3. Chan KA, Andrade SE, Boles M et al. Inhibitors of hydroxymethylglutaryl-coenzyme A reductase and risk of fracture among older women. Lancet 2000;355:2185–2188.
4. Reid LR, Hague W, Emberson J et al. Effect of pravastatin on frequency of fracture in the LIPID study: Secondary analysis of a randomized controlled trial. Lancet 2001;357:509–512.
5. Meier CR, Schlienger RG, Kraenzlin ME et al. HMG-CoA reductase inhibitors and the risk of fractures. JAMA 2000;283:3205–3210.
6. Van Stta TP, Wegman S, deVries F et al. Use of statins and risk of fractures. JAMA 2001;285:1850–1855.
7. Chan MH, Mak TW, Chiu RW et al. Simvastatin increases serum osteocalcin concentration in patients treated for hypercholesterolaemia. J Clin Endocrinol Metab 2001;86:4556–4559.
8. Chung YS, Lee MD, Lee SK et al. HMG-CoA reductase inhibitors increase BMD in type 2 diabetes mellitus patients. J Clin Endocrinol Metab 2000;85:1137–1142.
9. Edwards CJ, Hart DJ, Spector TD. Oral statins and increased bone-mineral density in postmenopausal women. Lancet 2000;355:2218–2219.
10. Wada Y, Nakamura Y, Koshiyama H. Lack of positive correlation between statin use and bone mineral density in Japanese subjects with type 2 diabetes. Arch Intern Med 2000;160:2865.

ORAL DRYNESS: SUBJECTIVE PERCEPTION AND OBJECTIVE CAUSES

To the Editor: Studies by Sreebny et al.[1,2] and by Edgar[3] have reported that about 30% of patients seen at a general medical practice complain of a dry mouth. Oral dryness is a common feature, especially in the elderly, with wearers of removable prosthetic appliances experiencing reduced oral comfort.

In addition to an age-dependent reduced salivary flow, other causes of xerostomia are discussed in the literature. These include the influence of oral dysfunction, the amount and kind of medication, and general health status.[4–7]

The questions being asked are: What factors have an objective influence on xerostomia, and which aspects are crucial to subjective perception of dry mouth?

To answer this question, we determined the resting and stimulated salivary flow rate of 83 women and 81 men with an average age of 69. According to the Wrigley study,[2] the threshold value was 0.1 mL/min or less for resting saliva and 0.5 mL/min or more for stimulated saliva.

The investigated values were analyzed in relation to age, sex, subjective perception, kind and quality of dental work, oral mucosal diseases, and systemic illness and medication.

RESULTS

Objective Outcome Measures

On the basis of the objective threshold value for the saliva flow rate, seven women and 12 men had hyposalivation, whereas 60 women and 66 men had normal salivary output (Figure 1). These 18 subjects could not be included in the comparative analysis because only one flow rate was low.

There was a highly significant intergroup difference with respect to age. Those with reduced salivary flow had an average age of 72, whereas the symptom-free probands had an average age of 68.

There was no significant relationship between hyposalivation and the kind of medication, sex, mucosal changes, or extent of palatal coverage.

Subjective Assessment

Sixty-seven subjects answered the question of subjective perception of oral dryness affirmatively. Within this group, 52 subjects with an average age of 68 (female:male ratio = 1:1) were interesting; they assessed the objective situation incorrectly, because their salivary flow rates were above the threshold values. The frequency of medication intake was 2.59 per day. In equal proportions, the palate

Osteoporos Int (2005) 16: 273–279
DOI 10.1007/s00198-004-1669-3

ORIGINAL ARTICLE

Trunk deformity is associated with a reduction in outdoor activities of daily living and life satisfaction in community-dwelling older people

Toshiaki Takahashi · Kenji Ishida · Daisuke Hirose
Yasunori Nagano · Kiyoto Okumiya
Masanori Nishinaga · Kozo Matsubayashi
Yoshinori Doi · Toshikazu Tani · Hiroshi Yamamoto

Received: 9 September 2003 / Accepted: 7 May 2004 / Published online: 2 July 2004

Abstract We have evaluated the association between trunk deformities of the sagittal plane and functional impairment of daily living in community-dwelling elderly subjects. The analysis involved a detailed assessment of indoor and outdoor activities of daily living, satisfaction with life, and mental status. The participants in this study were 236 community-dwelling older adults, aged 65 years and older, living in Kahoku district of Kochi in Japan. The participants were classified based on their posture, which was assessed using photographs of the subjects, and interviewed to assess their basic activities of daily living (BADL), instrumental ADL (IADL), and cognitive well-being in the cross-sectional study. The statistical analysis was performed using the Mann-Whitney *U*-test. The lumbar kyphosis group received significantly lower BADL and IADL scores than the normal group. The trunk deformity group which were defined as kyphosis, flat back, and lumbar lordosis groups exhibited decreases in activities that included going out, shopping, depositing and withdrawing money, and visiting friends in the hospital. These activities require going outdoors; thus, this study showed that the trunk deformity group had limitations in outdoor activities. There was no significant difference between the geriatric depression score (GDS) and the pattern of posture. The abnormal trunk deformity groups tended to score lower than the normal group with regard to subjective healthiness and life satisfaction measures, including subjective health condition, everyday feeling, satisfaction with human relationships, satisfaction with economic condition, and satisfaction with present life.

Keywords Activities of daily living · Kyphosis · Life satisfaction · Trunk deformity

T. Takahashi (✉) · K. Ishida · D. Hirose · Y. Nagano
T. Tani · H. Yamamoto
Department of Orthopaedics, Kochi Medical School,
Oko-cho, 783-8505 Nankoku, Kochi, Japan
E-mail: takahast@kochi-ms.ac.jp
Tel.: +81-88-8802387
Fax: +81-88-8802388

K. Okumiya · M. Nishinaga · Y. Doi
Department of Medicine and Geriatrics,
Kochi Medical School, Kochi, Japan

K. Matsubayashi
Center for Southeast Asian Studies, Kyoto University,
Kyoto, Japan

Introduction

Several studies have reported on the relationship between trunk deformity and lumbago [1,2]. It is predictable that patients with abnormal posture would be at increased risk for falling, as their balance is perturbed by the posture abnormality [3,4]. Loss of distal lumbar lordosis is the main cause of sagittal imbalance in individuals who do not maintain sagittal alignment [5]. This abnormal posture could lead to the limitation of daily activities.

There have been several evaluations of posture and functional activities to date [6]; however, very few involve elderly subjects. Ettinger et al. [7] reported that kyphotic women did not have greater back pain, disability caused by back problems, or poorer health than non-kyphotic women. Another study showed a poor correlation between quality of life and abnormal findings on radiography or densitometry [8].

Vertebral body compression fractures have been shown to be associated with the severity of kyphosis [9]. Ryan et al. [10] reported that there was a significant association between scores of osteoporosis severity and limitations in functional activity. Vertebral compression fractures associated with osteoporosis can be self-limiting, causing considerable pain and disability [8].

Vertebral compression fractures are associated with significant impairments in physical, functional, and psychosocial performance in the elderly [11,12,13]. It is crucial to improve the mental status of the elderly. However, there have been few reports regarding the

association between trunk deformity and psychogenic activity in elderly patients.

In this study, we have evaluated the daily activities and mental condition of community-dwelling elderly subjects with regard to the severity of trunk deformity in the sagittal plane.

Materials and methods

Subjects

Participants who applied in 1999 included 236 community-dwelling older adults, aged 65 years and older, living in Kahoku district in Kochi prefecture, who had been enrolled in one of several studies involving annual medical check-ups (beginning in 1994). The population of Kahoku rural area is 5800 people, 50% of whom are engaged in agricultural work.

Study participants were observed from July to August 1999, and then classified based on their posture, which was assessed using photographs taken by researchers. In total, there were 145 females (mean; 79.0 years) and 91 males (mean; 80.3 years) with a mean age of 80 years (range, 65–94 years), and a mean height of 149.1 cm. Functional status of the lumbar spine [14] and knee [15] were measured using the assessment of the Japanese Orthopaedic Association (JOA). In this study, JOA scores for assessing treatment of low back pain was calculated without incorporating urinary bladder function. Comorbidities were hypertension (31.6%), cardiac arrhythmia (6.1%), diabetes mellitus (5.7%), cerebrovascular disorder (4.2%), coronary artery disease (3.2%), senile dementia (2.1%), and Parkinson's disease (0.4%).

Methods

Interviews and examinations, conducted at the community plaza of Kahoku, consisted of a questionnaire covering physical health, functional status, and mental status. The analysis of trunk deformity was examined by photography. The presence or absence of disease was based on the subjects' self-report of a doctor's diagnosis. Informed consent was obtained from all participants.

Postural analysis

In order to protect the participants' privacy when undergoing the community health check-ups, we constructed a device with which to assess trunk posture without requiring that the subjects disrobe. Participants wore clothes typical of the summer season, and the device was equipped with a band that, when twisted, would reveal the alignment of the body. Each participant had reflective surface markers attached at various locations, including C7, T6 (xyphoid process level), L4 (Jacob line level), the left greater trochanter, the left lateral chondyle of the femur, and the left lateral malleous, as shown in Fig. 1. For the photograph, participants were positioned carefully and asked to remain relaxed while standing up straight. Posture in the sagittal plane was classified into one of the following five types: I normal, II thoracic

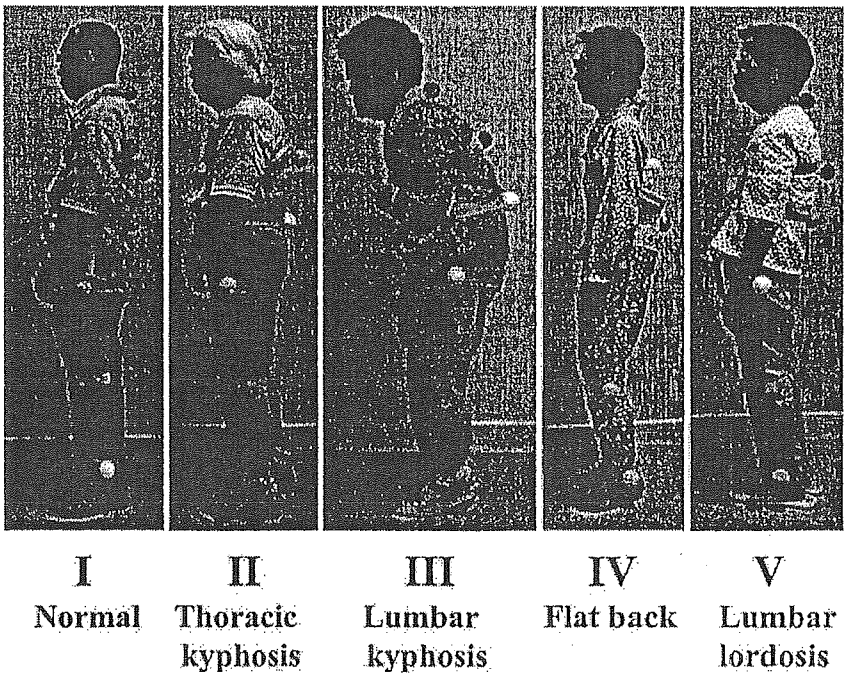

Fig. 1 Classification of trunk deformity from photographs

kyphosis, III lumbar kyphosis, IV flat back, and V lumbar lordosis, as described by Ando et al. [16,17,18]. Three orthopaedic doctors independently determined the classification, and we adopted the classification given by at least two doctors. In cases in which none of the doctors' classifications agreed, we discussed the case and jointly decided on the classification. The classification system is shown in Fig. 1, which includes photographs of patients representing each of the posture groups.

ADL analysis

The subjects were asked questions regarding basic activities of daily living (BADL) (walking, ascending and descending stairs, feeding, dressing, using the toilet, bathing, grooming, and taking medicine) and instrumental ADL (IADL) (using public transportation, shopping for groceries, preparing meals, paying bills, depositing and withdrawing money, writing, reading newspapers, reading magazines or books, taking an interest in news of health, visiting friends, giving advice to family or friends, visiting friends in the hospital, and talking to young people) [19]. We assessed the ADL score using a 4-point scale, based on the help required for each activity: 3 completely independent; 2 some help needed; 1 much help needed; and 0 completely dependent.

Mental state analysis

Geriatric Depression Scale

The Geriatric Depression Scale (GDS) [20,21], a measure of depressive symptomatology assessed on scale of 0–30, was administrated. We assessed the short form of 15 items, it is interpreted that a score >5 points is suggestive of depression, a score >10 points is almost always depression.

Visual analog scale (VAS)

Each year, we conducted an assessment of subjective quality of life (QOL), especially subjective healthiness and life satisfaction, using a validated self-reported visual analogue scale (VAS) [22]. The components of questions were subjective health condition, everyday feeling, satisfaction with human relationship to others, satisfaction with human relationship to family, satisfaction with economic condition, satisfaction with present life, and subjective happiness. The VAS questionnaire ended with a summing-up graph in the form of a 100 mm bar, graded with the subjectively worst condition on the left and the best one on the right. The subject was asked to place a mark on the 100 mm bar based on his or her condition. We defined the distance (mm) from the left to the marked position as the VAS score (0–100), with high scores indicating a high QOL [23].

Statistical analysis

For the classification of posture, Cohen's kappa coefficients were used to test statistical reliability. To determine inter-observer reliability, each reviewer's responses were compared with those of the other reviewers.

Data concerning ADL, GDS and life satisfaction were expressed by mean, SD, and SEM. The differences among the pattern of trunk deformities were evaluated using Kruskal-Wallis test, between with (II–V) and without trunk deformities (I) were evaluated using Mann-Whitney test. Differences were considered significant at $P<0.05$.

Results

The classification of trunk deformity resulted in five groups: I normal group (109 subjects; 46.2%), II thoracic kyphosis group (47 subjects; 19.9%), III lumbar kyphosis group (41 subjects; 17.4%), IV flat back group (28 subjects; 11.9%), and V lumbar lordosis group (11 subjects; 4.7%). There was a mean inter-observer kappa coefficient of 0.47 for both observation times, with a mean inter-observer agreement of 60.2%. We calculated a mean intra-observer kappa coefficient of 0.55 for the two observation times, with a mean inter-observer agreement of 68.3%. Table 1 shows the baseline characteristics in each group. There was no significant difference in age, sex, and overall health status such as comorbidities among the groups.

The mean BADL score of abnormal trunk posture (II–V) was 23.1; that of the normal (I) group was 23.6. The lumbar kyphosis group had significantly lower BADL scores than the normal group ($P=0.017$) (Table 2). With regard to BADL, walking was more likely to be limited in the abnormal trunk posture group (II–V) than in normal participants (I) ($P=0.02$).

The mean IADL score of abnormal trunk posture (II–V) was 10.3, that of the normal (I) group was 11.2. There was no significant difference in IADL among these groups ($P=0.1$) (Table 3). However, the abnormal posture groups (II–V) had lower IADL scores that differed significantly from the normal group (I) ($P=0.047$) (Table 3).

The achieved ratio of transportation of IADLs was associated with trunk deformity ($P=0.04$) (Table 4). The group with trunk deformity group had significant disturbances in certain IADLs, including transportation, shopping for groceries, depositing and withdrawing money, and visiting friends in the hospital (Table 4). Subjects with lumbar lordosis did not exhibit significant differences from the normal group, because of the small size of this group.

There was no significant difference between GDS and the pattern of trunk deformity ($P=0.70$) (Table 5). Measures of subjective healthiness and life satisfaction (Table 6), assessed using a validated, self-reported, visual analogue scale (VAS), were not significantly dif-

Table 1 Baseline characteristics of participants. All data are expressed as mean (95% confidence interval). *I* normal, *II* thoracic kyphosis, *III* lumbar kyphosis, *IV* flat back, and *V* lumbar lordosis

	I	II	III	IV	V	Total
Number	109	47	41	28	11	236
Age	78.4 (68.9, 87.8)	81.3 (71.3, 91.4)	80.8 (70.0, 91.8)	80.2 (70.9, 89.5)	80.6 (71.8, 89.5)	80
Gender (Female, Male)	55, 54	30, 17	34, 7	18, 10	7, 4	144, 92
Height	152.0 (133.5, 170.6)	145.7 (128.8, 162.7)	142.8 (126.3, 159.2)	150.8 (134.8, 166.9)	151.6 (133.4, 169.8)	149.1
Weight	54.3 (33.7, 74.9)	47.3 (33.1, 61.5)	47.4 (29.3, 65.5)	48.1 (31.0, 65.3)	53.0 (28.5, 77.5)	50.9
JOA score (lumbar)	25.6 (18.2, 33)	25.2 (18, 32.4)	24.1 (14.7, 33.5)	24.4 (15.4, 33.4)	27.5 (23.5, 31.5)	25.2
JOA score (knee)	92.0 (67.03, 116.9)	88.9 (59.18, 118.65)	88.0 (58.53, 117.45)	89.6 (66.81, 112.45)	93.3 (63.11, 123.49)	90.5
Coexisting illness						
Hypertension	34	15	17	6	2	74
Cardiac arrhythmia	5	4	4	1	0	14
Diabetes mellitus	5	2	2	3	1	13
Cerebrovascular disorder	3	2	2	1	0	10
Coronary artery disease	4	1	2	0	0	7
Senile dementia	1	2	0	2	0	5
Parkinson disease	0	0	1	0	0	1

Table 2 Total BADL score (points) by the classification of trunk deformity in comparison with the normal trunk group (I). *I* normal, *II* thoracic kyphosis, *III* lumbar kyphosis, *IV* flat back, and *V* lumbar lordosis

	Mean	SD	95% confidence intervals
I	23.6	0.9	21.8; 25.4
II	23.3	1.56	20.18; 26.42
III	22.7	3.81	15.08; 30.32
IV	23.3	1.76	19.78; 26.82
V	23.7	0.65	22.4; 25.0
II–V	23.1	2.51	18.1; 28.12

Table 3 Total IADL score (points) by the classification of trunk deformity in comparison with the normal trunk group (I). *I* normal, *II* thoracic kyphosis, *III* lumbar kyphosis, *IV* flat back, and *V* lumbar lordosis

	Mean	SD	95% confidence intervals
I	11.2	3.13	4.94; 17.46
II	10.6	3.09	4.42; 16.78
III	9.8	4.09	1.62; 17.98
IV	10	4.42	1.16; 18.84
V	12	1.41	9.18; 14.82
II–V	10.3	3.68	2.94; 17.66

ferent from normal in participants with trunk deformity ($P=0.08$). However, the abnormal trunk deformity group tended to have lower scores with regard to subjective health condition ($P=0.03$), everyday feeling ($P=0.007$), satisfaction with human relationships to family ($P=0.035$), satisfaction with economic condition ($P=0.03$), and satisfaction with present life ($P=0.051$) than those of the normal group.

Discussion

Trunk posture in the elderly, especially kyphosis, is known to be associated with vertebral compression fractures. Measurement of kyphosis may be useful in assessing the severity of spinal osteoporosis [9]. The high prevalence of back pain demonstrates the importance of pain management in the treatment of osteoporosis [24]. The number of recent vertebral fractures was also a significant predictor of poor performance in functional reach and walking speed tests [25]. Women with multiple vertebral deformities had significantly greater impairment of ADL function than women without such deformities [26].

Lyles et al. [12] showed that patients with vertebral compression fractures had reduced levels of functional performance, pain with activity, and difficulty in activities in comparison with patients that did not have fractures. Kyphosis is associated with qualitatively and quantitatively diminished function, especially with regard to the performance of mobility tasks [27]. Our results also showed that the walking activity of the

Table 4 The accomplished ratio (%) of IADL items compared between subjects with and without trunk deformity. Kruskal-Wallis test: among five groups, Mann-Whitney test: between with (II–V) and without trunk deformities (I). *I* normal, *II* thoracic kyphosis, *III* lumbar kyphosis, *IV* flat back, and *V* lumbar lordosis

Classification	I	II	III	IV	V	*P*-value	II–V	*P*-value
Going out using public transportation	93.1(%)	82.2(%)	75(%)	76.9(%)	77.8(%)	0.04	78.4(%)	0.003
Shopping for groceries	100	95.6	94.6	96	100	0.24	95.8	0.037
Preparing meals	98.1	93.5	91.9	92.3	100	0.37	93.3	0.09
Paying bills	99	93.3	94.6	92.3	100	0.27	94.1	0.052
Depositing and withdrawing money	98	91.3	91.9	88.5	100	0.17	91.7	0.035
Writing paper	93.2	83	86.5	80	100	0.13	85	0.053
Reading newspaper	82.4	75.6	67.6	76.9	90.9	0.32	74.8	0.17
Reading magazine or book	81	72.1	72.2	72	81.8	0.66	73	0.17
Taking an interest in news of health	97	90.7	86.5	91.7	100	0.17	90.4	0.052
Visiting friends	79	78.6	73	80	81.8	0.94	77.4	0.78
Giving advice to family or friend	85.1	75	73	80	100	0.19	77.6	0.16
Visiting friend in the hospital	98	89.1	91.9	88.5	100	0.12	90.8	0.023
Talking to young people	92.2	87	86.5	80.8	90.9	0.52	85.8	0.14

Table 5 Geriatric depression scale (GDS) by the classification of trunk deformity. *I* normal, *II* thoracic kyphosis, *III* lumbar kyphosis, *IV* flat back, and *V* lumbar lordosis

	Mean	SD	95% confidence intervals
I	5.8	3.65	−1.5; 13.1
II	5.9	3.79	−1.68; 13.48
III	6.6	3.76	−0.92; 14.12
IV	6.4	3.14	0.12; 12.68
V	5.4	3.78	−2.16; 12.96
II–V	6.2	3.62	−1.04; 13.44

abnormal trunk deformity group was more limited than that of normal participants. In contrast, kyphosis is associated with decreased bone mineral density (BMD) and loss of height, but does not cause substantial chronic back pain, disability, or poor health in older women [7]. However, previous studies have not assessed patterns of trunk deformity in the context of detailed assessments of functional impairment of daily living in the elderly.

In this study, we classified trunk deformity into five groups: I normal; II thoracic kyphosis; III lumbar kyphosis; IV flat back; and V lumbar lordosis. Previously, we reported that standing trunk posture was closely associated not only with distance and time parameters of gait, but also with functional performance measures such as functional reach and timed up and go tests in elderly subjects dwelling in a rural community [17]. In the present study, we evaluated if trunk deformity is associated with the results of a detailed assessment of indoor and outdoor activities of daily living, satisfaction with life, and mental status.

This study demonstrated that the lumbar kyphosis group had decreased activities of daily living, manifested primarily in the basic ADL of walking. Of the IADL, the trunk deformity group exhibited decreased activities of daily life such as going out, shopping, depositing and withdrawing money, and visiting friends in the hospital. These activities require going out of doors. This means the abnormal trunk deformity group experienced limited outdoor activities. The lumbar kyphosis group had greater interest in their own health, possibly because they have plenty of time to think about their own health at home, as their outdoor activities are limited.

So far, few reports have discussed the association between trunk deformity and mental status. However, vertebral deformity was shown to be associated with psychological morbidity in elderly Chinese women [28].

With regard to subjective healthiness and life satisfaction, there was no significant difference among the trunk deformity groups; however, the abnormal posture group tended to score lower than the normal group on measures of their own subjective health condition, everyday feeling, satisfaction with human relationships,

Table 6 Satisfaction-with-life score by the trunk deformity. Mann-Whitney test: between with (II–V) and without trunk deformities (I). *I* normal, *II* thoracic kyphosis, *III* lumbar kyphosis, *IV* flat back, and *V* lumbar lordosis

	Mean; SD		
	Normal (I)	Abnormal (II–V)	*P*-value
Subjective health condition	64.9; 17.85	59.3; 18.75	0.033
Everyday feeling	68.5; 18.56	61.7; 19.52	0.007
Satisfaction with human relationship to others	80.8; 16.31	77.6; 19.17	0.29
Satisfaction with human relationship to family	82.1; 14.55	77.5; 16.61	0.035
Satisfaction with economic condition	62.1; 20.91	55.6; 22.72	0.03
Satisfaction with present life	68.3; 20.55	62.5; 23.2	0.051
Subjective happiness	67.1; 20.09	64.0; 21.37	0.32
Total	457.8; 181.07	428.7; 155.95	0.08

satisfaction with economic condition, and satisfaction with present life. Therefore, the trunk deformity group experienced less subjective healthiness and satisfaction with life. This result may be explained by the limitation of outdoor activities that can lead to a limited social life and difficulty in enjoying a healthy and active life in the community.

Schreiner et al. reported that Geriatric Depression Scale was accurate and reliable in dementia among Japanese subjects [29]. Although the subjective impression of mental status in the trunk deformity group was not as favorable as that of normal group, the GDS in the trunk deformity group did not reveal significant difference in that of normal group. In another study, a significant association was found between BMD of the hip and depressive symptoms after adjustment for osteoporosis risk factors [30]. They suggested the relationship between low BMD and depression was associated with endogenous steroid. We should evaluate the GDS of the larger number of participants by the classification of trunk posture and detailed background of participants to clarify the relation of depression and spinal deformity.

In this study, we did not take X-rays of thoracic and lumbar lesions in the participants, and therefore cannot speculate on the association between spinal posture and vertebral fracture. Further examinations of the radiography of spine and bone densities, such as dual energy X-ray absorptiometry (DXA) or quantitative ultrasound, are necessary to assess the association between spinal posture and vertebral osteoporosis in the community-dwelling elderly. Further studies are also needed to evaluate the cause of the limitation in outdoor activities experienced by study participants with lumbar kyphosis, and to clarify and assess the relationship between mental status and trunk deformity through long-term follow-up.

In conclusion, patients in this study with trunk deformities exhibited decreases in activities that require going outdoors.The abnormal trunk deformity groups also tended to score lower than the normal group with regard to subjective healthiness and life satisfaction measures.

References

1. Takemitsu Y, Harada Y, Iwahara T, Miyamoto M, Miyatake Y (1988) Lumbar degenerative kyphosis: clinical, radiological and epidemiological studies. Spine 13:1317–1326
2. Lee CS, Lee CK, Kim YT, Hong YM, Yoo JH (2001) Dynamic sagittal imbalance of the spine in degenerative flat back. Significance of pelvic tilt in surgical treatment. Spine 26:2029–2035
3. Tinetti ME, Speechley M, Ginter SF (1988) Risk factors for falls among elderly persons living in the community. N Engl J Med 319:1701–1706
4. Maki B, Holliday P, Topper A (1994) A prospective study of postural balance and risk of falling in an ambulatory and independent elderly population. J Gerontol 49: M72–84
5. Gelb DE, Lenke LG, Bridwell KH, Blanke K, McEnery KW (1995) An analysis of sagittal spinal alignment in 100 asymptomatic middle and older aged volunteers. Spine 20:1351–1358
6. Krebs DE, Wong D, Jevsevar D, Riley PO, Hodge WA (1992) Trunk kinematics during locomotor activities. Phys Ther 72:505–514
7. Ettinger B, Black DM, Palermo L, Nevitt MC, Melnikoff S, Cummings SR (1994) Kyphosis in older women and its relation to back pain, disability and osteopenia: the study of osteoporotic fractures. Osteoporos Int 4:55–60
8. Cook DJ, Guyatt GH, Adachi JD, Clifton J, Griffith LE, Epstein RS, Juniper EF (1993) Quality of life issues in women with vertebral fractures due to osteoporosis. Arthr Rheum 36:750–756
9. Ensrud KE, Black DM, Harris F, Ettinger B, Cummings SR (1997) Correlates of kyphosis in older women. The Fracture Intervention Trial Research Group. J Am Geriatr Soc 45:682–687
10. Ryan PJ, Blake G, Herd R, Fogelman I (1994) A clinical profile of back pain and disability in patients with spinal osteoporosis. Bone 15:27–30
11. Hall SE, Criddle RA, Comito TL, Prince RL (1999) A case-control study of quality of life and functional impairment in women with long-standing vertebral osteoporotic fracture. Osteoporos Int 9:508–515
12. Lyles KW, Gold DT, Shipp KM, Pieper CF, Martinez S, Mulhausen PL (1993) Association of osteoporotic vertebral compression fractures with impaired functional status. Am J Med 94: 595–601
13. Oleksik A, Lips P, Dawson A, Minshall ME, Shen W, Cooper C, Kanis J (2000) Health-related quality of life in postmenopausal women with low BMD with or without prevalent vertebral fractures. J Bone Miner Res 15:1384–1392
14. Miyakoshi N, Abe E, Shimada Y, Okuyama K, Suzuki T, Sato K (2000) Outcome of one-level posterior lumbar interbody fusion for spondylolisthesis and postoperative intervertebral disc degeneration adjacent to the fusion. Spine 25:1837–1842
15. Takahashi T, Wada Y, Tanaka M, Iwakawa M, Ikeuchi M, Hirose D, Yamamoto H (2000) Dome-shaped proximal tibial osteotomy using percutaneous drilling for osteoarthritis of the knee. Arch Orthop Trauma Surg 120:32–37
16. Ando M, Yamamoto H, Nakatani K, Otani M (1986) Low back pain and trunk posture of elder people in a rural district. Seikeigeka bessatu 12:14–17 (in Japanese)
17. Hirose D, Ishida K, Nagano Y, Takahashi T, Yamamoto H (2004) Posture of the trunk in the sagittal plane is associated with gait in community-dwelling elderly population. Clin Biomech 19:57–63
18. Staffel F (1989) Die menschlichen haltungs typen. J.F. Bergman, Wiesbaden
19. Matsubayashi K, Okumiya K, Osaki Y, Fujisawa M, Doi Y (1999) Frailty in elderly Japanese. Lancet 353:1445
20. Gerety C (1982) Medical evaluation of the geriatric patient. In: Katz MS (ed) Geriatric medicine. Churchill Livingstone, New York
21. Norris JT, Gallagher D, Wilson A, Winograd CH (1987) Assessment of depression in geriatric medical outpatients: the validity of two screening measures. J Am Geriatr Soc 35:989–995
22. Morrison DP (1983) The Crichton Visual Analogue Scale for the assessment of behaviour in the elderly. Acta Psychiatr Scand 68:408–413
23. Matsubayashi K, Okumiya K, Osaki Y, Fujisawa M, Doi Y (1997) Quality of life of old people living in the community. Lancet 350:1521–1522
24. Liu-Ambrose T, Eng JJ, Khan KM, Mallinson A, Carter ND, McKay HA (2002) The influence of back pain on balance and functional mobility in 65- to 75-year-old women with osteoporosis. Osteoporos Int 13: 868–873
25. Huang C, Ross PD, Wasnich RD (1996) Vertebral fracture and other predictors of physical impairment and health care utilization. Arch Int Med 156: 2469–2475
26. Jinbayashi H, Aoyagi K, Ross PD, Ito M, Shindo H, Takemoto T (2002) Prevalence of vertebral deformity and its associ-

ations with physical impairment among Japanese women: the Hizen-Oshima Study. Osteoporos Int 13:723–730
27. Ryan SD, Fried LP (1997) The impact of kyphosis on daily functioning. J Am Geriatr Soc 45:1479–1486
28. Lau EMC, Woo J, Chan H, Chan MKF, Griffith J, Chan YH, Leung PC (1998) The health consequences of vertebral deformity in elderly Chinese men and women. Calcif Tissue Int 63:1–4
29. Schreiner AS, Hayakawa H, Morimoto T, Kakuma T (2003) Screening for late life depression: cut-off scores for the Geriatric Depression Scale and the Cornell Scale for depression in dementia among Japanese subjects. Int J Geriatr Psychiatr 18:498–505
30. Robbins J, Hirsch C, Whitmer R, Cauley J, Harris T (2001) The association of bone mineral density and depression in an older population. J Am Geriatr Soc 49:732–736

J Rehabil Med 2004; 36: 42–45

Taylor & Francis
healthsciences

VERTICAL GROUND REACTION FORCE SHAPE IS ASSOCIATED WITH GAIT PARAMETERS, TIMED UP AND GO, AND FUNCTIONAL REACH IN ELDERLY FEMALES

Toshiaki Takahashi,[1] Kenji Ishida,[1] Daisuke Hirose,[1] Yasunori Nagano,[1] Kiyoto Okumiya,[2] Masanori Nishinaga,[2] Yoshinori Doi[2] and Hiroshi Yamamoto[1]

From the [1]Department of Orthopaedic Surgery, Kochi Medical School, Kochi, [2]Department of Medicine and Geriatrics, Kochi Medical School, Kochi, Japan

Objective: **The aim of this study was to evaluate the relationship between knee pain and various indicators of the combined performance of the lower extremity (including gait parameters, functional performance such as timed up and go, and functional reach test) and to determine whether the classification of vertical ground reaction forces correlates with gait parameters and functional performance.**

Subjects and Methods: **Simultaneous analysis of gait, time-distance parameters and vertical ground reaction force. Timed up and go, and functional reach test were examined in 130 elderly women. The vertical component of the ground reaction force was grouped into 2 categories: M-shaped and non-M-shaped.**

Results: **No significant association was found between knee pain and timed up and go, functional reach test, or gait parameters in elderly female participants. There were significant differences between subjects with M- and non-M-shaped vertical ground reaction forces with regard to timed up and go, functional reach test and Japan Orthopaedic Association score. There were also significant differences between the 2 groups (M shaped and non-M-shaped) in gait parameters.**

Conclusion: **Evaluation of the vertical ground reaction force to determine its shape may be a useful and simple tool in the analysis of gait and functional performance.**

Key words: knee pain, gait analysis, elderly females, ground reaction force, osteoarthritis.

J Rehabil Med 2004; 36: 42–45

Correspondence address: Toshiaki Takahashi, Department of Orthopaedic Surgery, Kochi Medical School, Oko-cho, Nankoku, Kochi, 783-8505, Japan. E-mail: takahast@kochi-ms.ac.jp

Submitted January 22, 2003; Accepted August 25, 2003

INTRODUCTION

Osteoarthritis of the knee is one of the most common diseases in elderly females. There are several ways of testing locomotor function of the lower extremity, including measures of muscle strength, gait analysis and some types of knee evaluation scales (1–3). However, there is limited evidence that these parameters are highly correlated with the functional state of the knee. Gait analysis is becoming recognized as an important clinical tool in orthopaedics, in pre-surgery planning, post-surgery monitoring and in a posterior evaluation of various corrective interventions (4, 5). However, it is sometimes difficult for clinicians to analyse the large amounts of data gathered in the assessment of gait time and distance parameters (5).

Objective quantitative assessment of mobility and balance is important for older people because problems with gait and balance can result in a restriction of activity. The Timed Up and Go (TUG) test correlates with gait speed, balance and movement of the lower extremities (6). The Functional Reach (FR) test is a simple measurement of standing balance that can predict falls in elderly people (7, 8).

There have been several reports concerning gait analysis in osteoarthritis of the knee (1, 9). The vertical ground reaction force (VGRF) has been shown to be a reliable and repeatable feature of gait (10–11). There have been numerous studies regarding ground reaction forces during walking (12–14). Gait speed significantly affects VGRF (12, 13, 16). The VGRF varies continually from the instant of initial contact until the foot leaves the supporting surface (17). Body mass, proportions, walking style and balance all affect VGRF (17).

There have been only a few reports regarding the relationship between VGRF and various gait parameters in elderly females with osteoarthritic knees. Analyses that include a classification of VGRF have also been limited. Thus, in this study, we focused on the vertical ground force component, classified into 2 groups: M-shaped, also known as a "dual-hump" shape (18) and non-M-shaped. The purpose of this study was to evaluate the relationship between knee pain and various indicators of the combined performance of the leg, including gait parameters, functional performance, TUG and FR and to determine whether the classification of VGRF is correlated with gait parameters and functional performance.

MATERIAL AND METHODS

Subjects

We defined the subjects with osteoarthritic knee as having knee pain and less than 100 points of Japan Orthopaedic Association (JOA) score. We have been performing annual medical checks of adults aged 65 years and

 ISSN 1650–1977
DOI 10.1080/16501970310018297

Table I. *Japan Orthopaedic Association scores based on the osteoarthritic knee evaluation form*

Pain on walking (maximum 30 points)	*Score*
No pain, walking unlimited	30
Pain, walking unlimited	25
Pain, walking distance of 0.5–1 km	20
Pain, walking less than 0.5 km	15
Pain, walking only indoors	10
Cannot walk	5
Cannot stand	0
Pain on ascending or descending stairs (maximum 25 points)	
No pain	25
Pain, relieved by using handrails	20
Pain, with handrails, but no pain with each step	15
Pain, with each step, pain relieved by using handrails	10
Pain, with each step even with handrail use	5
Cannot ascend or descend	0
Range of motion (maximum 35 points)	
Kneeling	35
Sideways or cross-legged sitting	30
More than 110°	25
75°–109°	20
35°–74°	10
Less than 35°	0
Joint effusion (maximum 10 points)	
No effusion	10
Occasional puncture required	5
Frequent puncture required	0
Maximum total points	100

over who live in the community in Kahoku of Kochi prefecture since 1994. We then examined the locomotor ability of the subjects.

The mean age of the 130 participants was 80 years (range 65–94 years), with a mean height of 143.0 cm. Knee pain while walking was classified into 3 groups: no pain (45%), unilateral pain (28%) or bilateral pain (26%).

Average maximum flexion for all subjects was 140.9 ± 13.4 degrees. Average maximum extension was 5.2 ± 6.1 degrees. JOA scores determined from the osteoarthritic knee evaluation form (Table I) were used for the evaluation of knee function (19). JOA (0–100 points) scores averaged 90.1 ± 12.9 points. The distance between the medial chondyles was evaluated, and averaged 2.5 ± 1.4 fingers breadth.

Co-morbidities of the subjects included hypertension (31.6%), cardiac arrhythmia (6.1%), coronary artery disease (3.2%) and diabetes mellitus (5.7%). Eighteen subjects with the following conditions were excluded from this study: knee disorders after total knee arthroplasty (5 patients), high tibial osteotomy (2 patients), miscellaneous knee operations (2 patients), osteosynthesis (1 patient), multiple cerebral infarctions (7 patients) and Parkinson's disease (1 patient).

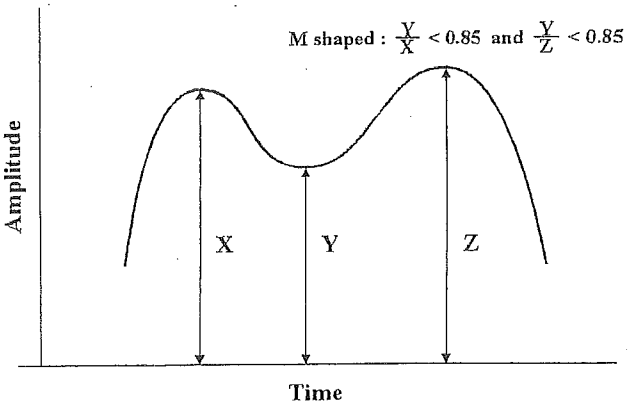

Fig. 1. Calculation of M-wave shape of vertical ground reaction force. M-shaped was defined as Y/X and Y/Z less than 0.85. All others were defined as non-M-shaped.

Gait analysis

The interviewer asked to record the gait parameters of subjects who were able to walk a distance of 10 metres. Subjects were allowed to wear their usual clothes and use their preferred (normal) speed while walking a 7-metre-long course. The first and last 2–3 metres on the walkway were not considered for measurement.

A Gait Scan® 8000 (Nitta Co. Ltd, Osaka, Japan) of gait-pattern measurement system consisting of a thin-film sensor walkway, a computer for automatic recording of the data was used in this study. This gait analysis device consists of a sensor seat (264 × 52 cm), a connector unit which fixes the sensor seat, and an interface board with a personal computer and software for data analysis.

Gait parameters, temporal distance and time factors, and ground reaction forces were measured simultaneously. Ground reaction force data for both legs was collected at a self-selected walking speed. The peak force was measured as the highest VGRF that occurred anytime during the stance phase, while the lowest VGRF occurred during the mid-stance phase.

Patients were classified into 2 groups based on the VGRF: M-shaped and non-M-shaped (Fig. 1). We defined M-shaped as lowest/highest × 100 (%) of less than 85. We assessed the shape of the VGRF for every step and classified individuals based on the result that was obtained for the greater number of steps. The mean gait variables measured in this study were walking speed (metres/sec), stride length, step width (cm), time of stride, time of single stance and time of double stance (sec). The distance parameters of stride length and step width were normalized for the height of the subject (15).

Functional performance

Timed up and go

To measure TUG, subjects were given oral instructions to stand up from

Table II. *Data (mean (SD)) for patients without pain, with unilateral and bilateral pain in elderly females*

	No pain ($n = 59$)	Unilateral pain ($n = 37$)	Bilateral pain ($n = 34$)
Body weight (kg)	45.2 (7.53)	47.2 (7.49)	52.2 (8.94)
Timed up and go (sec)	13.0 (3.0)	13.8 (4.51)	15.1 (7.28)
Functional reach (cm)	20.6 (7.2)	21.0 (7.07)	23.1 (6.89)
Stride length (cm)	63.2 (9.21)	61.1 (11.7)	61.7 (10.9)
Stride width (cm)	5.4 (2.20)	5.7 (2.14)	5.6 (1.92)
Time of stride (sec)	1.1 (0.117)	1.1 (0.179)	1.2 (0.167)
Time of single stance (sec)	0.58 (0.059)	0.59 (0.073)	0.60 (0.082)
Time of double stance (sec)	0.16 (0.037)	0.17 (0.052)	0.18 (0.069)
Gait speed (m/s)	0.6 (0.115)	0.56 (0.147)	0.54 (0.135)

Table III. *Participant characteristics given as mean (SD)*

	Height (cm)	Weight (kg)	JOA (point)	TUG (sec)	FR (cm)
Right side					
M-shaped ($n = 32$)	143.8 (7.2)	46.1 (8.6)	95.2 (10.3)	11.6 (2.3)	22.5 (6.9)
Non-M-shaped ($n = 47$)	142.4 (5.2)	45.9 (7.4)	86.6 (13.5)	14.6 (4.5)	18.4 (8.2)
	$p = 0.187$	$p = 0.96$	$p = 0.0013$	$p < 0.0001$	$p = 0.026$
Left side					
M-shaped ($n = 29$)	143.1 (8.1)	45.8 (8.1)	96.9 (6.25)	11.35 (2.25)	22.9 (7.56)
Non-M-shaped ($n = 50$)	142.9 (4.7)	46.2 (7.8)	86.1 (14.1)	14.5 (4.44)	18.45 (7.74)
	$p = 0.41$	$p = 0.92$	$p = 0.0002$	$p < 0.0001$	$p = 0.026$

JOA: Japan Orthopaedic Association; TUG: timed up and go; FR: functional reach

a chair, walk 3 metres as quickly and as safely as possible, cross a line marked on the floor, turn around, walk back and sit down (6).

Functional reach. FR represents the maximal distance a subject can reach forward beyond arm's length while maintaining a fixed base of support in the standing position (7, 20).

Statistics

Data were expressed as a mean and standard deviation (SD). Differences between groups were evaluated using a Kruskal Wallis test for the analysis of knee pain (Table II) and a Mann-Whitney U test for the analysis of VGRF (Tables III and IV). Statistical significance was set at $p < 0.05$.

RESULTS

Occurrence of knee pain showed a significant association with body weight; however, there was no significant difference between patients with or without pain and TUG, FR, or any gait parameters (Table II).

The shape of the VGRF was associated with certain measures of functional performance, as well as the JOA score (Table III). Patients exhibiting an M-shaped VGRF on the right and left sides had shorter TUGs and longer FRs than patients with a non-M-shaped VGRF. The total JOA score was greater for the M-shaped group than for the non-M-shaped group. Within both groups, the ground reaction forces were similar on left and right sides.

Several gait parameters varied according to the shape of the VGRF (Table IV). Stride length was longer for the M-shaped VGFR group than for the non-M-shaped VGRF group. The times of stride and single and double stance were shorter in the M-shaped VGRF group than in the non-M-shaped group. The walking speed of the M-shaped group was faster than that of the non-M-shaped group. There was no significant difference between the 2 groups in the step width on both sides.

DISCUSSION

Osteoarthritis of the knee is common in elderly females and it is well-known that it is associated with gait disturbances. There have been numerous reports regarding the relationship between osteoarthritis and gait parameters. An evaluation of the relationship between gait parameters and knee pain in elderly females found no significant association between knee pain and gait parameters or functional performance. Findings such as these have suggested that numerous factors, such as the posture of the trunk, lumbar lesions, the condition of other joints (such as the hip and ankle) and mental status, all contribute to gait parameters in elderly females. Therefore, it is important to consider these factors in the analysis of people with knee pain.

An advantage of gait analysis as a diagnostic or research tool is that many factors can be assessed at one time; however, proper evaluation of the resulting data can be complex. Quantitative data of time and distance parameters of gait analysis is difficult to understand and interpret whether it is within normal or not.

One study showed no overall abnormality in the shape or amplitude of the ground reaction force measured for the natural gait of knee-pain subjects (21). The present study, which involved the evaluation of one simple aspect of the VGRF (classified as M-shaped and non-M-shaped), showed that the shape of the ground reaction force was correlated with the pain

Table IV. *Gait parameters (mean (SD)) for subjects with M-shape and non-M-shape of vertical ground reaction force*

	Stride length (cm)	Step width (cm)	Time of stride (sec)	Time of single stance (sec)	Time of double stance (sec)	Gait speed (m/s)
Right side						
M-shaped ($n = 32$)	70.1 (8.7)	5.5 (2.1)	1.03 (0.09)	0.5 (0.04)	0.1 (0.02)	0.7 (0.11)
Non-M-shaped ($n = 47$)	55.8 (89.9)	5.8 (2.3)	1.2 (0.15)	0.6 (0.07)	0.2 (0.047)	0.5 (0.1)
	$p < 0.0001$	$p = 0.712$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Left side						
M-shaped ($n = 29$)	70.6 (9.2)	5.5 (2.08)	1.0 (0.087)	0.54 (0.042)	0.1 (0.02)	0.69 (0.12)
Non-M-shaped ($n = 50$)	56.5 (9.9)	6.0 (2.47)	1.8 (0.15)	0.61 (0.075)	0.2 (0.046)	0.5 (0.11)
	$p < 0.0001$	$p = 0.146$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

component of the JOA score. In another study, increased gait speed was associated with shorter force periods and larger peak forces (16).

In the present study we found that there were no differences between the right and left legs with respect to gait parameters, functional performance or the shape of the ground reaction force. Consistent with our findings, another study showed no significant differences between the right and left foot with respect to ground reaction force during walking (22).

In our study we found that both gait parameters and functional performance were significantly correlated with the shape of the VGRF. Several previous studies have examined VGRFs in normal subjects and patients with osteoarthritis; however, prior to the present study, there was little known concerning the relationship between the VGRF and gait parameters or functional performance in elderly females with knee osteoarthritis. In one study it was found that the 2 peaks in the vertical component measured for the affected side in knee-osteoarthritis patients became less apparent, with significantly lower magnitudes than in normal subjects (18). In addition, patterns of VGRFs were nearly identical during overground and treadmill walking (23) and the general waveform and its characteristic features did not seem to be affected by the sex of normal subjects (18). In the present study, we could not find a correlation between pain and the mechanism of the shape of VGRF. Further study is needed to clarify the changing mechanism of VGRF in osteoarthritic knee.

In the present study, we did not examine inter-rater reliability: future study is needed to investigate this and the validity with respect to M-shape and gait analysis.

In conclusion, our classification of VGRF is a simple and useful tool for assessment of gait function. It was correlated with many parameters of gait and functional performance, such as TUG and functional reach. Our study indicated that a change in the VGRF, from non-M-shaped to M-shaped, is crucial to the improvement of gait parameters and gait performance. Further studies are needed to seek methods for altering the shape of the ground reaction force.

ACKNOWLEDGEMENTS

We thank all staff members and elderly residents of Kahoku in Kochi prefecture who were involved in this study.

REFERENCES

1. Murray MP, Gore DR, Sepic SB, Mollinger LA. Antalgic maneuvers during walking in men with unilateral knee disability. Clin Orthop 1985; 199: 192–200.
2. Prince F, Corriveau H, Hebert R, Winter DA. Gait in the elderly. Gait Posture 1997; 5: 128–135.
3. Stauffer RN, Chao EYS, Gyory AN. Biomechanical gait analysis of the diseased knee joint. Clin Orthop 1977; 126: 246–255.
4. Kaufman KR, Sutherland DH. Future trends in human motion analysis. In: Harris GF, Smith PA, eds. Human motion analysis. Current applications and future directions. New York: IEEE Press; 1996, p. 187–215.
5. Bertani A, Cappello A, Benedetti MG, Simoncini L, Catani F. Flat foot functional evaluation using pattern recognition of ground reaction data. Clin Biomech 1999; 14: 484–493.
6. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991; 39: 142–148.
7. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. J Gerontol 1990; 45: 192–197.
8. Weiner DK, Duncan PW, Chandler J, Studenski SA. Functional reach: a marker of physical frailty. J Am Geriatr Soc 1992; 40: 203–207.
9. Goh JC, Bose K, Khoo BC. Gait analysis study on patients with varus osteoarthritis of the knee. Clin Orthop 1993; 294: 223–231.
10. Kadaba MP, Ramakrishnan HK, Wootten ME, Gainey J, Gorton G, Cochran GVB. Repeatability of kinematic, kinetic, and electromyographic data in normal adult gait. J Orthop Res 1989; 7: 849–860.
11. Olsson E, Oberg K, Ribbe T. A computerized method for clinical gait analysis of floor reaction forces and joint angular motion. Scand J Rehabil Med 1986; 18: 93–99.
12. Andriacchi TP, Ogle JA, Galante JO. Walking speed as a basis for abnormal gait measurements. J Biomech 1977; 10: 261–268.
13. Alexander RM, Jayes AS. Fourier analysis of forces exerted in walking and running. J Biomech 1980; 13: 383–390.
14. Balmaseda MT, Koozekanani SH, Fatehi MT, Gordon C, Dreyfuss PH, Tanbonlinog EC. Ground reaction forces, center of pressure, and duration of stance with and without an ankle-foot orthosis. Arch Phys Med Rehabil 1988; 69: 1009–1112.
15. Chao EY, Laughman RK, Schneider E, Stauffer RN. Normative data of knee joint motion and ground reaction forces in adult level walking. J Biomech 1983; 16: 219–233.
16. Nilsson J, Thorstensson A. Ground reaction forces at different speeds of human walking and running. Acta Physiol Scand 1989; 136: 217–227.
17. Cook TM, Farrell KP, Carey IA, Gibbs JM, Wiger GE. Effects of restricted knee flexion and walking speed on the vertical ground reaction force during gait. J Orthop Sports Phy Ther 1997; 25: 236–244.
18. Schneider E, Chao EY. Fourier analysis of ground reaction forces in normals and patients with knee joint disease. J Biomech 1983; 16: 591–601.
19. Takahashi T, Wada Y, Tanaka M, Iwagawa M, Ikeuchi M, Hirose D, Yamamoto H. Dome-shaped proximal tibial osteotomy using percutaneous drilling for osteoarthritis of the knee. Arch Orthop Trauma Surg 2000; 120: 32–37.
20. Okumiya K, Matsubayashi K, Wada T, Kimura S, Doi Y, Ozawa T. Effects of exercise on neurobehavioral function in community-dwelling older people more than 75 years of age. J Am Geriatr Soc 1996; 44: 569–572.
21. Radin EL, Yang KH, Riegger C, Kish VL, O'Connor JJ. Relationship between lower limb dynamics and knee joint pain. J Orthop Res 1991; 9: 398–405.
22. Herzog W, Nigg BM, Read LJ, Olsson E. Asymmetries in ground reaction force patterns in normal human gait. Med Sci Sports Exerc 1989; 21: 110–114.
23. White SC, Yack HJ, Tucker CA, Lin HY. Comparison of vertical ground reaction forces during overground and treadmill walking. Med Sci Sports Exerc 1998; 30: 1537–1542.

Heart Failure in the Elderly

Naohito YAMASAKI, Hiroaki KITAOKA, Yoshihisa MATSUMURA, Takashi FURUNO, Masanori NISHINAGA and Yoshinori DOI

Abstract

Heart failure is common in the elderly population. Approximately 6 to 10 percent of the population 65 years or older have heart failure. Heart failure is the most common reason for hospitalization in elderly patients. Etiology of heart failure is often multifactorial in the elderly. The common causes of heart failure include ischemic heart disease, valvular heart disease, hypertensive heart disease, and cardiomyopathy. Exacerbation of heart failure in the elderly is often accompanied by precipitating factors which include arrhythmia, renal failure, anemia, infection, adverse effect of drugs and noncompliance with medication and/or diet. Diagnosis of heart failure may be difficult in the elderly because symptoms of heart failure are often atypical or even absent. Heart failure with preserved systolic function is common in the elderly because aging has a greater impact on diastolic function. It is important to recognize that very old patients with heart failure are underrepresented in clinical trials.
(Internal Medicine 42: 383–388, 2003)

Key words: heart failure, elderly, diastolic dysfunction

Introduction

Heart failure (HF) is the pathophysiological state in which the heart is unable to pump blood at a rate sufficient to meet metabolic demands or can do so only from an elevated filling pressure.

HF is common in the elderly population. Approximately 6 to 10 percent of the population 65 years or older have HF (1). In the Framingham study, the prevalence of HF was shown to rise progressively with age, from 1 percent of persons in their 50s to 10 percent of persons in their 80s (2, 3) (see Fig. 1). HF is the most common reason for hospitalization in elderly patients (2, 3). Approximately 80 percent of all HF admissions occur in patients older than 65.

Etiology of HF in the Elderly

HF is a clinical syndrome and can be caused by virtually any form of heart disease. The distribution of causes of HF depends on what kind of patients with HF are selected.

In the population-based study conducted in Framingham, MA, USA, the common causes of HF were ischemic heart disease (54%), hypertensive heart disease (24%), and valvular heart disease (16%) (3). In a hospital-based study done in Fukuoka, Japan, the frequent causes of HF were ischemic heart disease (35%), valvular heart disease (28%), hypertensive heart disease (20%), and cardiomyopathy (19%) (4) (see Fig. 2). Differences in patient selection and/or racial variation may explain these results.

Distribution of causes of HF in the elderly in Japan is thought to be similar to that in Fukuoka study since the mean age of patients was 69 years and 70 percent of the patients were >65 years of age, although it was not designed to specifically examine the elderly. Also, the etiology of HF in the elderly is often multifactorial as shown in the Fukuoka study.

Ischemic heart disease

Ischemic heart disease is the most common cause of HF in the elderly. The severity and extent of coronary atherosclerosis increases with age, presumably as a result of prolonged exposure to coronary risk factors. Elderly patients more frequently have multivessel disease and lower ejection fraction than do younger patients (5). Non-Q wave myocardial infarction is relatively common in the old population.

In the elderly, silent myocardial ischemia (presence of coronary artery disease without symptoms) is common. Myocardial infarction may not be recognized by some of the elderly patients due to lack of chest discomfort. It may be discovered only on subsequent routine ECG (unrecognized myocardial infarction). The prevalence of unrecognized myocardial infarction increases with age. In one study, unrecognized myocardial infarction was more than 5% prevalent in the group aged 75 to 79 years compared to nearly none in the youngest age group (6). Common initial presentation of myocardial infarction in the elderly is shortness of breath and easy fatiguability without symptom of chest pain.

From the Department of Medicine and Geriatrics, Kochi Medical School, Kochi
Reprint requests should be addressed to Dr. Yoshinori Doi, the Department of Medicine and Geriatrics, Kochi Medical School, Oko-cho, Nankoku-shi, Kochi 783-8505

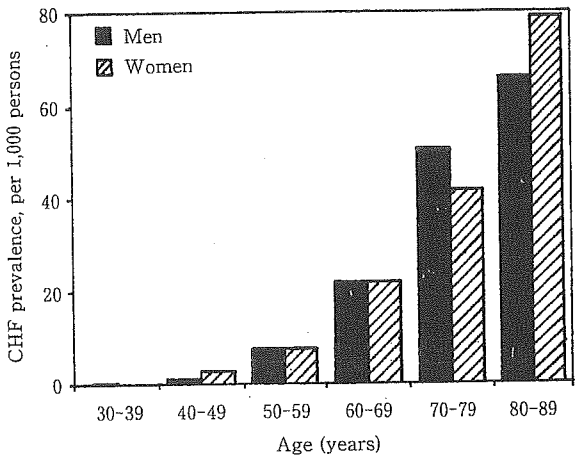

Figure 1. Prevalance rates of heart failure among Framingham heart study subjects, by gender and age (3).

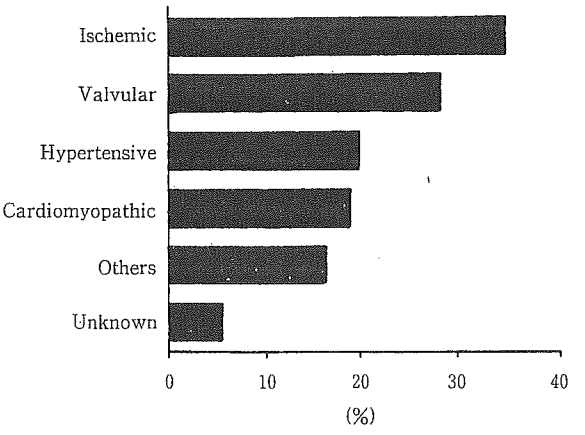

Figure 2. Causes of heart failure in Fukuoka, Japan. Patients could have more than one cause of heart failure. Numbers denote the percentage of patients to the total number of study patients (4).

Hypertensive heart disease

Hypertensive heart disease is a common cause of HF in old patients with a long-standing history of hypertension. Isolated diastolic dysfunction which often accompanies with hypertensive heart disease can cause HF in the presence of preserved systolic function. Left ventricular dilatation and systolic dysfunction may occur at the advanced stage of hypertensive heart disease, if wall stress remains high because of inadequate hypertrophy.

Valvular heart disease

Aortic stenosis is the most common valvular disease that requires surgery in the elderly. The most frequent cause of aortic stenosis in the elderly is degenerative calcification of the tricuspid aortic valve that accounts for almost half of the patients with aortic stenosis who are 70 years of age or older. In contrast, in patients younger than 70 years, calcification of congenital bicuspid aortic valves accounts for half of the cases (7). Mitral regurgitation due to mitral valve prolapse or ruptured chordae tendinae is also common in the elderly.

Although rare, isolated severe tricuspid regurgitation can be at times a cause of HF in the elderly (8). This usually occurs in elderly patients with long history of atrial fibrillation (AF) and is characterized by severe right-sided heart failure with preserved left ventricular systolic function. The tricuspid annulus is markedly dilated without organic leaflet lesion in this condition. AF is known to cause annular dilatation of tricuspid valve and significant tricuspid regurgitation (9). Tricuspid regurgitation begets farther annular dilatation and then becomes more severe. This vicious circle may be responsible for this disease.

Cardiomyopathy

Both dilated and hypertrophic cardiomyopathies occur in the elderly. Dilated cardiomyopathy can cause HF in the elderly just as in younger patients. Hypertrophic cardiomyopathy is being diagnosed increasingly in elderly patients. In patients with hypertrophic cardiomyopathy, cardiac hypertrophy is usually evident by the end of the accelerated adolescence growth period. However, expression of hypertrophy may often be delayed until middle age or old age in patients caused by cardiac myosin-binding protein C gene mutations (10, 11). Although the prognosis of elderly patients with hypertrophic cardiomyopathy is favorable, HF due to progressive left ventricular dilation and systolic dysfunction does occur in a small number of patients (so-called, "dilated phase hypertrophic cardiomyopathy"). In our experience, 4 out of 14 hypertrophic cardiomyopathy patients caused by cardiac myosin-binding protein C gene mutations progressed to the dilated phase later in their lives and they deteriorated clinically (12).

Senile cardiac amyloidosis

Cardiac amyloidosis should be suspected in elderly patients with HF and a hypertrophied left ventricle. Amyloidosis is classified according to protein identity of the deposited amyloid (13). The most common form of cardiac amyloidosis is AL amyloidosis (formerly called primary amyloidosis). In AL amyloidosis, the amyloid protein is composed of monoclonal immunoglobulin light chain. Plasma cell dyscrasia is responsible for the excess light chain production. Patients with AL amyloidosis have a poor prognosis with a median survival of 5.4 months when presented with HF.

Senile amyloidosis is not uncommon among elderly patients with cardiac amyloidosis, although the exact incidence is not known. In senile amyloidosis, amyloid deposit consists of transthyretin, a transport protein for thyroxine and retinol-binding protein. Patients with senile cardiac amyloidosis have a better prognosis with the actuarial median survival of 5 years compared to those with AL amyloidosis. These pa-