week. Soya bean curd, which is an important potential source of calcium in the Chinese diet, was eaten at least once a week by 35% of controls but by only 27% of patients. In contrast to the data from Southampton, calcium was found to protect against fracture in both women and men. In the past low calcium intake might have been offset by a high level of weight bearing physical activity, which maintained bone mass. The decline in activity which followed the construction of high rise apartments and the disappearance of walking space may have unmasked the adverse skeletal effect of a low calcium intake.

Public health strategies to reduce the rising incidence of hip fractures in urbanising oriental populations are urgently required. Our results point to the importance of maintaining physical activity and calcium intake in elderly Chinese people who grew up in rural communities, characterised by high levels of physical activity and a diet low in calcium, but are now mostly living in flats in high rise buildings while continuing to eat a traditional diet.

This study was supported by a grant from the Wellcome Trust. We acknowledge Dr Y Chow and Dr D Lau of Queen Elizabeth Hospital and Dr P C Lee of Kwong Wah Hospital for their help in recruiting patients. We thank Miss R To and Mrs F Cheng, who interviewed the subjects; Mr A Cheang, who helped with the analysis; and Mrs P Tam and Mrs B Wilde for the secretarial support.

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(Accepted 20 September 1988)

Physical activity, muscle strength, and calcium intake in fracture of the proximal femur in Britain

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Abstract

Regular exercise and high calcium intake possibly help to preserve bone mass. Little is known, however, about their role in preventing hip fracture. The physical activity and calcium intake of 300 elderly men and women with hip fractures were compared with those of 600 controls matched for age and sex. In both sexes increased daily activity, including standing, walking, climbing stairs, carrying, housework, and gardening protected against fracture. This was independent of other known risk factors, including body mass, cigarette smoking, and alcohol consumption. Strength of grip correlated with activity and was inversely related to the risk of fracture. Calcium intake was not related to the risk of fracture in women. Men with daily calcium intakes above 1g had lower risks.

These findings point to the importance of elderly people in Britain maintaining physical activity in their day to day lives.

Introduction

Hip fractures in elderly people are an important public health problem. Osteoporosis and falls are two known aetiological factors.[1] Regular exercise and high calcium intake, measures that possibly preserve bone mass,[2] offer the main immediate population based strategy for preventing osteoporosis. Little information, however, is available about their role in preventing hip fracture,[3] and hence no scientific basis exists for recommending them as part of a national preventive campaign. We used validated methods to compare physical activity and calcium intake in a series of elderly patients with hip fractures and community controls. We measured the independent contribution of each of these two factors to the risk of hip fracture after allowing for the confounding effects of other known risk factors, which include low body mass, cigarette smoking, and alcohol consumption.[3]

Patients and methods

We recruited 473 patients aged 50 and over who lived in Southampton health district and were admitted sequentially to the orthopaedic wards of this hospital. Fifteen patients died before they could be approached, and 12 declined to participate. The remaining 446 completed a 10 point Hodkinson abbreviated mental test score,[4] and the 300 patients (240 women and 60 men) who scored more than 6 became the study group. We estimated that a study of this size had a 90% power of detecting a relative risk of 1·7 or more in women and 3·0 or more in men at the five per cent level of significance, assuming a 30% exposure of the controls to a dichotomous risk factor.

Patients in the study group were compared with 600 community controls, resident in the same district, who were selected from the register of Hampshire Family Practitioner Committee. Controls were individually matched to the patients in the study group by sex and age within four years. The rate of response among controls was 71% of those contacted. When a control refused to participate or failed the mental test score a substitute was selected.

All patients in the study group and the controls were interviewed by one of three trained interviewers. Each case-control set was seen by the same interviewer. Patients were interviewed in hospital within ten days of admission. Controls were interviewed within three months of their matched patient (68%) or during the corresponding quarter a year later (32%).

Physical activity in the six weeks before the interview was estimated with a validated questionnaire for the assessment of customary activity in the elderly.[5] Five indices of current activity were derived: self reported walking speed, time spent standing indoors, time spent walking outdoors, frequency of muscle loading activity such as climbing stairs or carrying loads, and time spent in productive activities such as gardening and housework.

Current calcium intake was measured with a frequency and amount questionnaire, which obtained information about the consumption of six food items: milk, bread, cheese, puddings, cakes, and biscuits. A Department of Health survey of elderly people in Britain suggested that 87% of their total calcium intake was derived from these food items.[6] We have shown previously that estimates of calcium intake with this questionnaire correlate well with those derived from

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duplicate diet analysis and six day weighed inventories.[7] The strength of grip was measured with an isometric dynamometer. The maximum of three readings on each hand was used for subsequent analysis.

TABLE I—*Distribution of 446 patients with hip fracture by age, sex, and mental test score*

			Mental test score			
	All		>5		≤5	
Age (years)	Women	Men	Women	Men	Women	men
<55	3	6	3	6		
55-	12	9	11	8	1	1
65-	55	18	50	16	5	2
75-	142	30	99	22	43	8
>84	155	16	77	8	78	8
Total	367	79	240	60	127	19

The data were analysed with a conditional logistic regression for matched case-control studies, which produced relative risks and 95% confidence intervals.[8] The significance of gradients of relative risk was assessed with χ^2 tests for linear trend. Relations between variables were studied with multiple linear regression or analysis of covariance.

TABLE II—*Distribution of risk factors for hip fracture among 300 patients with hip fracture and 600 matched controls**

Variable	No (%) of patients	No (%) of controls	Relative risk	95% Confidence interval
Body mass index (kg/m²) in fifths of distribution:				
Lowest	88 (32)	84 (15)	6·7	3·8 to 11·7
Second	67 (24)	94 (17)	4·3	2·4 to 7·4
Third	60 (22)	112 (20)	3·3	1·9 to 5·8
Fourth	40 (14)	128 (23)	2·1	1·2 to 3·8
Highest	24 (9)	144 (26)	1·0	
Cigarette smoking	145 (48)	223 (37)	1·7†	1·2 to 2·3
Alcohol consumption:				
Moderate or heavy	28 (9)	12 (2)	7·5	3·3 to 16·8
Light	108 (36)	205 (34)	1·3	1·0 to 1·8
Occasional or abstainer	163 (55)	382 (64)	1·0	
History of stroke	34 (11)	39 (7)	1·8	1·1 to 2·9
Current use of corticosteroids	16 (5)	13 (2)	2·7	1·2 to 5·8
History of a fall in the previous nine months	112 (37)	153 (26)	1·8	1·3 to 2·5
Previous hip fracture after age 50	37 (12)	14 (2)	6·8	3·4 to 13·8
Previous wrist fracture after age 50	48 (16)	52 (9)	2·3	1·4 to 3·6
Gait abnormality:				
Walks only with help of another person	32 (11)	23 (4)	4·3	2·4 to 7·9
Walks with stick	126 (42)	199 (33)	1·9	1·4 to 2·6
Walks unaided	142 (47)	377 (63)	1·0	
Mental test score:				
6 and 7	62 (21)	62 (10)	3·1	1·9 to 4·8
8	36 (12)	60 (10)	1·6	1·0 to 2·5
9	53 (18)	113 (19)	1·2	0·8 to 1·7
10	149 (50)	365 (61)	1·0	
Dependence in daily living activities:				
Requires help in three or more activities	28 (9)	21 (3)	4·4	2·3 to 8·4
Requires help bathing and dressing	38 (13)	34 (6)	3·4	2·0 to 5·8
Requires help bathing	77 (26)	124 (21)	1·9	1·3 to 2·8
Fully independent	157 (52)	420 (70)	1·0	

*Information was not available for all subjects.
†Relative risk refers to that between those who had ever smoked and those who had never smoked.

Results

Table I shows the age and sex distribution of the 300 patients whose mental test score was over 5 and the 146 whose score was 5 or under. The 146 patients were older than the 300, and their female to male ratio was greater. More of them were living in supervised accommodation (warden controlled flats, rest homes, and nursing homes).

Table II shows the distribution among patients and controls of variables found to be associated with risk of fracture. The risk declined progressively with rising body mass index and mental test score and increasing independence in daily living activities. The risk was increased by cigarette smoking, alcohol consumption, a history of stroke, current use of corticosteroids, a fall during the previous nine months, previous hip or wrist fractures, and inability to walk unaided.

No difference was detected in the mean age at menarche or the menopause of patients and controls. Eighteen of the women with hip fractures (8%) and 22 female controls (5%) recalled having had an oophorectomy, giving a relative risk of 1·5, which was not, however, significant at p=0·05 (95% confidence interval 0·9 to 3·2). The previous use of postmenopausal hormone replacement treatment was reported by six patients (3%) and 23 controls (5%), giving a relative risk of 0·5, which again was not significant (0·2 to 1·3).

PHYSICAL ACTIVITY

We analysed the risk of hip fracture in relation to each of the five indices of current physical activity (table III). Among women the risk of fracture increased significantly ($p<0·05$) with shorter standing times, lower self reported walking speeds, and

TABLE III—*Physical activity and risk of hip fracture in 300 patients with hip fracture and 600 matched controls**

	Women					Men				
			Relative risk					Relative risk		
Activity	No of patients (n=240)	No of controls (n=480)	Non-adjusted	Adjusted†	95% Confidence interval	No of patients (n=60)	No of controls (n=120)	Non-adjusted	Adjusted†	95% Confidence interval
Standing time (mins/day):										
None	15	21	2·9	1·6	0·5 to 4·6	0	2			
1-	84	102	3·1	2·9	1·7 to 4·9	16	23	1·9	2·1	0·6 to 7·5
30-	76	152	1·9	1·8	1·1 to 2·9	18	30	1·6	1·9	0·7 to 5·0
≥60	65	205	1·0	1·0		26	65	1·0	1·0	
Self reported walking speed:										
Very slow	132	207	2·4	2·6	1·3 to 5·2	23	36	1·5	1·6	0·5 to 5·7
Easy pace	46	114	1·4	1·5	0·7 to 3·0	17	34	1·2	0·9	0·3 to 2·9
Normal speed	40	90	1·5	1·5	0·7 to 3·1	10	27	0·9	0·9	0·2 to 3·4
Brisk/fast	22	68	1·0	1·0		10	23	1·0	1·0	
Walking time (mins/day):										
None	126	236	1·4	0·8	0·4 to 1·8	24	43	2·5	3·4	0·8 to 15·1
1-	79	154	1·3	0·9	0·4 to 2·0	23	35	2·8	2·7	0·7 to 10·8
30-	21	57	0·9	0·8	0·3 to 2·0	7	16	1·9	4·2	0·8 to 23·1
≥60	14	33	1·0	1·0		6	26	1·0	1·0	
Muscle loading activity (frequency):										
Never	89	131	2·0	1·7	1·0 to 3·1	13	22	4·6	2·5	0·5 to 13·2
Less than weekly	63	112	1·6	1·7	1·0 to 3·1	19	19	7·9	5·6	1·3 to 23·9
Weekly to daily	42	117	0·9	1·0	0·6 to 1·8	18	32	3·5	3·6	1·0 to 12·9
Several times a day	46	120	1·0	1·0		10	47	1·0	1·0	
Productive activity (hours/week):										
None	66	212	2·7	2·0	1·1 to 3·7	10	13	2·7	2·4	0·5 to 12·0
1-	52	105	3·4	3·3	1·9 to 5·7	15	13	4·2	3·8	1·1 to 13·6
3-	66	77	1·8	1·8	1·0 to 2·9	14	31	1·8	3·2	0·9 to 11·3
≥5	56	86	1·0	1·0		21	63	1·0	1·0	

*Information was not available for all subjects.
†Adjusted for body mass index, smoking, alcohol, stroke, and steroid treatment.

TABLE IV—*Mean grip strength (kg) (95% confidence interval) by age and sex of patients with hip fracture and controls*

Age (years)	Women: No of patients (n=238)	Women: No of controls (n=479)	Men: No of patients (n=60)	Men: No of controls (n=120)
<55	30·0 (16·9 to 43·1)	27·4 (24·0 to 30·8)	40·5 (27·2 to 53·8)	39·9 (33·3 to 46·5)
55-	23·7 (18·2 to 29·2)	23·8 (20·5 to 27·0)	33·8 (25·7 to 41·8)	42·6 (36·9 to 48·3)
65-	18·3 (16·4 to 20·3)	20·9 (19·6 to 22·2)	27·2 (22·0 to 32·4)	33·5 (29·4 to 37·6)
75-	13·5 (12·4 to 14·5)	17·6 (16·8 to 18·4)	22·1 (19·1 to 25·1)	25·4 (22·6 to 28·2)
>84	10·7 (9·8 to 11·6)	13·0 (12·1 to 13·8)	15·4 (11·5 to 19·2)	20·5 (16·1 to 24·9)

TABLE V—*Distribution of grip strength and risk of hip fracture in patients with hip fracture and controls**

Fifths of the distribution of grip strength (kg)	No of patients	No of controls	Relative risk: Non-adjusted	95% Confidence interval	Adjusted†	95% Confidence interval
			Women			
<10	60	64	4·9	2·7 to 9·0	2·7	1·4 to 5·5
10-	64	82	4·3	2·4 to 7·7	3·1	1·6 to 5·9
14-	51	99	2·5	1·4 to 4·5	1·7	0·9 to 3·2
18-	33	116	1·3	0·7 to 2·3	1·0	0·5 to 1·8
≥23	30	118	1·0		1·0	
			Men			
<18	15	20	4·9	1·3 to 18·9	1·9	0·4 to 9·5
18-	16	17	6·7	1·7 to 26·1	2·4	0·5 to 12·0
25-	13	27	2·1	0·7 to 6·7	1·4	0·4 to 5·5
31-	7	28	0·9	0·3 to 3·3	0·7	0·2 to 3·1
≥39	9	28	1·0		1·0	

*Information was not available for all subjects.
†Adjusted for body mass index, smoking, alcohol, stroke, and steroid treatment.

TABLE VI—*Dietary calcium intake and risk of hip fracture in patients with hip fracture and controls*

Fifths of the distribution of calcium intake (mg/day)	No of patients	No of controls	Relative risk: Non-adjusted	95% Confidence interval	Adjusted*	95% Confidence interval
			Women			
<433	47	97	1·0	0·6 to 1·6	1·2	0·7 to 2·2
433-	51	93	1·1	0·7 to 1·8	1·4	0·8 to 2·5
567-	48	96	1·0	0·6 to 1·7	1·1	0·6 to 2·0
684-	47	97	1·0	0·6 to 1·6	1·2	0·7 to 2·1
≥838	47	97	1·0		1·0	
			Men			
<500	15	21	4·6	1·4 to 15·0	6·2	1·3 to 29·7
500-	14	22	4·0	1·2 to 13·0	5·8	1·1 to 29·0
668-	14	22	3·6	1·2 to 11·1	3·3	0·8 to 14·1
841-	12	24	3·2	0·9 to 11·3	6·2	1·2 to 32·7
≥1041	5	31	1·0		1·0	

*Adjusted for body mass index, smoking, alcohol, stroke, and steroid treatment.

less frequent muscle loading and productive activity. Similar increases in risk among men were associated with less activity. The number of men was smaller, and the increases were not significant. Body mass index, cigarette smoking, alcohol consumption, history of stroke, and use of corticosteroids (table II) were thought to be possible confounding variables—that is, independently associated with physical activity and hip fracture. We therefore examined the relation between physical activity and the risk of fracture after adjusting for these variables (table III), but this did not greatly affect the trend.

MUSCLE STRENGTH

Table IV shows the variation of strength of grip with age and sex. It fell sharply with age in both patients in the study group and controls. The mean strength in each age group was greater in men than in women. We calculated the risk of fracture for men and women in each fifth of the distribution of grip strength (table V). There was an almost fivefold increase in risk between the lowest and highest fifths of strength. This increase was significant for both women ($p<0·001$) and men ($p=0·001$). The risk of fracture remained significantly ($p<0·001$) increased in women with reduced grip strength after allowing for all the confounding variables, and though this increased risk remained in men, it was not significant ($p=0·20$). After we allowed for age and sex, grip strength was significantly ($p<0·01$) related to each of the five indices of activity in both patients in the study group and controls.

CALCIUM INTAKE

The mean daily calcium intake of the controls was 651 mg for women (interquartile range 467-799 mg) and 843 mg for men (interquartile range 560-1042 mg). Table VI shows the relative risks of fracture in women and men in each fifth of the distribution of calcium intake. Among women there was no change in risk with increasing calcium intake. In men there was a fall in risk with increasing intake. This trend did not remain after adjusting for the five confounding variables, but the adjusted risk among men with the highest intakes, more than 1041 mg/day, remained significantly lower than that among the rest.

Discussion

The results of this study suggest that inactivity and muscle weakness are associated with an increased risk of hip fracture in elderly people. In both sexes less physical activity as measured by four of the five indices was associated with a doubling of risk of fracture (table III). There were fewer men than women, however, so estimates for men were less certain and not significant at $p=0·05$.

Selecting people with mental test scores of six or more led to the exclusion of around one third of patients but fewer controls. Although patterns of activity are likely to be different in people with low mental test scores, we think it unlikely that this would create a false association between inactivity and risk of fracture.

The risk of fracture increased steeply with lower strength of grip in both sexes. Part of this association may be explained by loss of strength as a result of fracture. Strength of grip, however, correlated with reported levels of physical activity. The differences in grip strength between patients and controls were therefore unlikely to be solely a consequence of fracture. Activity and muscle strength could protect against hip fracture either by preserving bone mass or by reducing the risk and severity of falls. Several reports suggest an association between exercise and bone mass.[9-12] A relation between activity, muscle strength, and falling has been found in a national sample of 1000 elderly people in Britain.[13] Lower levels of both mobility and grip strength were associated with an increased frequency of reported falls.

Among women there was no relation between the risk of fracture and the intake of calcium. Among men, after we had adjusted for confounding variables, the risk was lower in those in the highest fifth of calcium intake. Evidence that either hip fractures or osteoporosis are related to dietary calcium intake is inconsistent. A comparison of two populations in Yugoslavia showed a higher incidence of hip fracture in the one with the lower calcium intake.[14] Two case-control studies, however, did not show associations between calcium intake and the risk of fracture.[15 16] Studies on metabolic balance show a drop in the efficiency of mechanisms that maintain calcium balance with increasing age. This is particularly noticeable in postmenopausal women.[17] Trials of calcium supplementation, however, have shown little, if any, beneficial effect on the rate of bone loss.[18 19] Our results suggest that in elderly women in southern Britain low calcium intake is not a risk factor for hip fracture. In men, however, our results support a protective effect with a calcium intake above 1 g a day, an intake recorded in only 7·5% of the women studied.

We conclude that physical inactivity and muscle weakness are both associated, independently of other influences, with an increased risk of hip fracture in elderly people. This points to the importance of maintaining physical activity in the day to day lives of old people.

We thank the consultants and staff of the department of orthopaedic surgery, Southampton General Hospital, and the general practitioners of the Southampton health district; Mrs M Mitchell and Mrs S Underwood interviewed some of the patients; Mr G Butcher helped in selecting controls; Dr E J Bassey and Dr H Dallosso of the department of physiology and pharmacology, University of Nottingham Medical School, helped with the method of assessing physical activity; and Dr W J Boyce, Northampton health district, advised on the design of the study.

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(Accepted 20 September 1988)

Effects of withdrawal of co-danthramer on use of laxatives in a district general hospital

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In March 1987, after new evidence that long term administration of high doses of danthron was associated with tumours in rodents, the manufacturers of co-danthramer (Dorbanex and Dorbanex Forte) surrendered product licences for these preparations.[1] At this hospital co-danthramer was used extensively as a result of routine prescribing and a policy permitting nursing staff to administer up to three doses of the liquid laxative without a prescription, a ruling also applied to senna tablets. After the withdrawal the drugs and therapeutics subcommittee issued guidance that treatment of constipation should be based on dietary or prescribed fibre, though if a stimulant laxative was necessary senna provided a suitable alternative to co-danthramer. Senna syrup replaced co-danthramer as the liquid laxative to be given by nurses. Lactulose was discouraged as a first line laxative, being unsuitable for administration as required and fairly expensive. This guidance was supplemented by a bulletin from the district drug information centre.

We looked at use of laxatives before and after the withdrawal of co-danthramer and assessed changes in view of the recommendations made.

Method and results

Use of laxatives by inpatients was measured from data on the pharmacy computer on issues to the wards. This information was converted to defined daily doses, a unit defined as the assumed average daily dose of the drug when used for its main indication in adults.[2] The values used were determined after consultation with colleagues. To relate defined daily dose to patient numbers we determined the number of occupied bed days recorded for the hospital and then calculated the number of defined daily doses used per 100 occupied bed days.[3,4] Use of laxatives was compared for two periods of six months (April to September) in 1986 and 1987, one before and the other after the withdrawal of co-danthramer. Financial data were also considered to assess the implications in terms of cost of changing patterns of use of laxatives.

The results confirmed that co-danthramer liquid was the most used laxative preparation in 1986 (at 10·9 defined daily doses per 100 occupied bed days), accounting for 37% of all laxative use, with lactulose and ispaghula sachets ranked second and third (table).

Use of laxatives from April to September, 1986 and 1987. Values are expressed as defined daily doses per 100 occupied bed days

Laxative	1986	1987
Co-danthramer liquid	10·9	
Lactulose	6·4	10·9
Ispaghula sachets	5·5	4·4
Glycerin suppositories	2·2	2·4
Senna tablets	1·3	3·9
Senna syrup	0·1	5·9
Phosphate enemas	0·7	0·8
Sodium citrate enemas	0·6	0·9
Bisacodyl suppositories	0·2	0·6
Docusate sodium 100 mg tablets	0·2	0·7
Other preparations	0·6	0·3

The total use of laxatives rose from 29·3 defined daily doses per 100 occupied bed days in 1986 to 31·3 in 1987, when lactulose was the most commonly used agent. The use of ispaghula fell in 1987 while use of senna preparations, particularly the syrup, showed a pronounced rise. Expenditure on laxatives rose considerably after the withdrawal of co-danthramer, from £1986 for the six months in 1986 to £3274 for the corresponding period in 1987.

Comment

The total use of laxatives increased by 7% from 1986 to 1987, whereas expenditure rose by 65%. Even allowing for inflation and price rises, this suggests that costs increased because expensive preparations were used rather than because of a large increase in use.