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Original Article

Independent Living after Fractures in the Elderly

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Abstract. Although fractures are an important source of disability among the growing elderly populations of industrialized societies, patient-centered multidimensional outcome information is scarce. The purpose of this study was to quantify the natural history of recovery from fractures of the upper and lower extremities. From the 1994/95 WHO MONICA survey in Augsburg, Germany, we selected all persons aged 58–78 years who had experienced a fracture during the preceeding 10 years, along with a control population twice as large. The Health Assessment Questionnaire (HAQ) and the Medical Outcomes Study Short Form 36 (SF-36) were administered to these subjects in 1998. Patients' recollection of fracture type and location were validated against medical records. The most recent fracture was in the upper extremity in 45 cases, lower extremity in 55 cases and elsewhere in 46 cases. Extremity fractures resulted in persistent and measurable impairment of the activities of daily living or general quality of life in patients 65 years or older, especially if the femur was involved. More than 40% of the interindividual variation of functional disability in the study group could be explained by age, sex, history of a fracture within 12 years and perceived difficulties walking. Existing generic and specific musculoskeletal outcome measurement instruments thus allow the assessment of functional recovery and health status after fractures in an elderly population. Geriatric assessment following fractures at higher age may improve ability to live independently. Difficulty walking deserves special attention, as it is associated with more general functional disability among the elderly.

Keywords: Activities of daily living; Fracture; Independence; Osteoporosis; Outcomes

Introduction

Fractures are an important source of disability among the growing elderly populations of industrialized societies, and are increasing even more rapidly than these populations themselves. Total medical costs of osteoporotic fractures have been estimated as US$ 13.7 billion in 1995 for the USA, one-third of which are attributable to fractures other than hip fractures [1–3]. While prevention of these events either through maintaining bone strength or through avoiding trauma is clearly desirable, improvements in rehabilitation after such events have occurred may lead to reduced disability and expense. Increasing emphasis is being placed on patient-centered, multidimensional generic and specific health outcome measures in the assessment of health impact and functional recovery after osteoporotic fractures [4]. However, information on both generic and specific outcomes following fractures of appendicular bones in the elderly and their change over time is scarce. We therefore sought to investigate the natural history of recovery from fractures of the upper and lower extremities in an elderly population using existing outcome measures and to evaluate factors which might increase the likelihood of independent living after such injuries.

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Materials and Methods

Cooperative Health Research in the Region of Augsburg, Germany (KORA, Kooperative Gesundheitsforschung in der Region Augsburg) is a large, continuing population-based cohort study which emanated from a follow-up of the WHO's multinational MONICA project [5,6].

We identified all persons aged 58–78 years who had entered the study by the survey 1994/95 and who had experienced a fracture of the extremities during the 10 years before this examination. A control population twice as large, matched by age and sex, was randomly selected from subjects who denied having had a fracture during this period. Controls were identified primarily from the 1994/95 survey information, and were reclassified as cases if a fracture occurred prior to the follow-up examination in 1998. Both cases and controls underwent a supervised questionnaire and anthropometric measurements to investigate the types of fracture, methods of treatment and resumption of independent living after the fracture had occurred. This questionnaire included a previously validated German translation of the Health Assessment Questionnaire (HAQ), a patient-centered outcomes instrument specific for musculoskeletal conditions [7–9]. A score of zero on the HAQ indicates unimpaired function in its various domains, while 3 indicates the worst outcome. Internal consistency of the HAQ was checked both for fracture patients and for controls using the Cronbach alpha statistic. Independence was defined using the Functional Disability Index (FDI) calculated from the HAQ, where a score of 3 indicates a person who is totally disabled in all areas (feeding, ambulation, hygiene, etc.) and 0 indicates complete independence. The FDI [10] is calculated by adding the scores for each of its eight components (dressing and grooming, arising, eating, walking, hygiene, reach, grip) and dividing by the number of components answered. Each component consists of at least two questions, and the highest score for any question within the component determines the score of this component.

This measurement instrument was supplemented by a more general health status measure, the Medical Outcomes Study Short Form 36 (SF-36), for which a validated German version also exists [11–13]. Health status in the domains of this instrument is expressed as a percentage of perfect function. The SF-36 comes from a larger battery of questions administered in the Medical Outcomes Study. It includes eight multi-item scales containing 2 to 10 items each and a single item to assess health transition. The scales cover the dimensions of physical health, mental health, social functioning, role functioning, general health and vitality. The use of subscales is encouraged and the questionnaire can be self-administered or interviewer-administered. The SF-36 is the most widely used general health status instrument and has been translated into many languages. It allows scoring of the eight subscales and the construction of two summary scales: the physical component scale (PCS) and the mental component scale (MCS). The physical component scale of the SF-36 consists of the subscales physical functioning, physical role function, bodily pain and general health. The best possible score of 100 can exert a ceiling effect in a healthy general population.

Multiple physical and sociologic variables were considered as potential risk factors for fracture or as predictors of independent living after suffering a fracture. Comorbidity was assessed by a league table of chronic conditions, which had been validated earlier [14]. Social contacts were measured by the Berkman-Syme social network index. Cases were stratified by sex and by age group ($\leqslant 65$ and >65 years). The effect of a fracture on independence was estimated from a linear regression with multivariable adjustment for all factors listed in Table 2, and a prediction model was generated by backward elimination of variables for which coefficients were not statistically significant ($p<0.05$). The effect of a fracture was also estimated for different times after injury as the coefficient of a multiple linear regression equation relating FDI to an indicator variable equal to 1 if there were a fracture within the specified time period and 0 for controls (with other cases excluded), while also controlling for age, sex and the age $\times$ sex interaction.

Results

The data were all collected within the calendar year 1998. We identified 146 cases and 311 controls. Slightly less than 60% were female. Due to regrouping of controls as cases when a fracture had occurred since the last visit, there is a mild gender imbalance in the raw data between groups with comparable age distributions. Women with a history of osteoporosis were more likely to be in the fracture group ($p = 0.017$). Otherwise, within age and sex groups, univariate and multivariate analysis did not show any significant association with smoking, socioeconomic, employment or marital status. For women, history of childbirth, breast-feeding or perimenopausal hormone intake were not significantly related to the occurrence of fracture. Table 1 describes the basic demography, anthropometry and comorbidity of the study population.

Over two thirds of the subjects understood 'independent living' to include 'being healthy' and 'being able to do everything', while only a few mentioned financial aspects. Illness was most frequently cited as the main threat to independence, while political, social or financial concerns were only occasionally mentioned. Only a third of cases reported feeling no threat to their independence. Less than one fifth of the study population felt well-informed on issues related to adaptation of their accommodation, alternative living arrangements or medical supplies (13.1%, 15.8% and 16.2%). It appears that health issues are central to the pursuit of independent living in the elderly population.

The most recent fractures reported by cases are shown in Table 2. Among those with a lower extremity fracture,

Table 1. Demography, anthropometry and comorbidity

Variable	Category	Control	Case	Total
Status case/control	*n*	311	146	457
Gender	Male	142	53	195
	Female	169	93	262
Age (years)	Mean	66.7	66.9	66.8
	SD	5.9	5.6	5.8
Age category (years)	Up to 64 years	120	54	174
	65 years and over	176	86	262
Known osteoporosis	No	259	118	377
	Yes	33	27	60
Depression/mental illness	No	277	129	406
	Suffer from	30	17	47
Depression (M-CIDI)[a]	No	280	129	409
	Yes	25	16	41
Dizziness/disturbed balance	No	221	104	325
	Suffer from	87	42	129
Difficulty walking	No	262	112	374
	Suffer from	46	34	80
Disturbed vision/eye disease	No	47	41	88
	Suffer from	261	105	366
Stroke/neurologic disease	No	289	137	426
	Suffer from	19	7	26
Social network index[b]	low 1	2	2	4
	med 2–5	101	59	160
	med–high 6–7	101	35	136
	high 8–12	95	45	140
Body mass index (kg/m^2) above/below median	<28 kg/m^2	155	74	229
	>28 kg/m^2	156	72	228
Body fat (%)	Mean	34.21	35.48	34.63
	SD	7.67	8.17	7.85
Comorbidity category (points)[c]	0–1 points	35	22	57
	2–3 points	84	34	118
	>3 points	189	90	279
Time since last fracture (years)	0–1 years	–	3	3
	2 years	–	6	6
	3 years	–	23	23
	4 years and over	–	114	114

[a]Diagnosis by standardized Interview (M-CIDI: Munich Composite Diagnostic Interview).
[b]Berkman-Syme index.
[c]Calculation by number of comorbidities (1 point each), associated medication (add 1 point) and perceived disability (add 1 point).

Table 2. Most recent fracture among the 146 cases

Location	No. of cases		Years since injury Mean (SD)
	Male	Female	
Upper extremity	14	31	–
Humerus	1	2	9.3 (3.8)
Radius/ulna	5	22	8.1 (4.0)
Hand	8	7	–
Lower extremity	19	36	–
Femur (hip)	2	5	6.0 (1.7)
Tibia/fibula	9	23	7.5 (3.9)
Foot	8	8	–
Other	20	26	–
Total	53	93	7.5 (3.6)

only 2 men and 5 women had fractured the proximal femur. In more than half of cases, a fall was the cause of the fracture. Other fractures included the clavicle, scapula or multiple locations.

Overall internal consistency of the HAQ was 0.80 for cases and 0.66 for controls (Cronbach's alpha). Self-assessment of health (answering 'good' or 'excellent' to the question 'How is your health?') correlated only moderately well with the FDI (r = 0.48). A backward regression model using all variables in Table 2 with age, sex and case/control status as forced-in variables was able to explain more than 50% of the observed variance in the FDI. The largest contribution was made by the presence or absence of a gait disturbance. An interaction term between difficulty walking and having suffered any fracture was insignificant. Other influential factors were a history of stroke, depression, femoral fracture, the time elapsed since a fracture, general comorbidity, elevated body mass index and reduced social contacts. A parsimonious model containing only difficulty walking in addition to the forced-in variables was able to explain more than 40% of the variance (Table 3). An attempt was made to validate the findings against other outcome measures of physical function. To this end, the domains physical functioning (PF), role physical (RP) and the

Table 3. Linear regression models predicting the functional disability index (FDI)

Model	Variable	Unstandardized coefficients β	Standardized coefficients β	*p*	95% confidence interval for β	
					Lower bound	Upper bound
1	(Constant)	–0.224	–	0.118	–0.505	0.057
	Gender	0.096	0.081	0.026	0.011	0.181
	Age > 65 years	0.049	0.041	0.254	–0.035	0.132
	Case/control	0.011	0.009	0.799	–0.076	0.099
	Difficulty walking	0.809	0.540	0.000	0.698	0.921
	Comorbidity	0.120	0.145	0.000	0.060	0.181
	Fx 0–1 years	0.600	0.087	0.014	0.123	1.077
	Fx of femur	0.331	0.073	0.040	0.016	0.647
	Stroke/ND	0.316	0.128	0.000	0.141	0.491
	Social network index	–0.055	–0.079	0.028	–0.103	–0.006
	BMI	0.107	0.092	0.009	0.027	0.187
	Depression/Mental illness	0.143	0.075	0.034	0.011	0.274
2	(Constant)	–0.194	–	0.030	–0.368	–0.019
	Gender	0.157	0.134	0.000	0.071	0.242
	Age > 65 years	0.101	0.085	0.023	0.014	0.187
	Case/control	0.031	0.025	0.495	–0.058	0.119
	Difficulty walking	0.942	0.626	0.000	0.835	1.050

Variables included in the model for backward elimination included all variables from Table 1 and variables coding for fracture of the humerus, radius/ulna, femur and tibia/fibula. Adjusted R^2 model 1 = 0.52; R^2 model 2 = 0.44.
FX, fracture; ND, neurologic disease; BMI, body mass index.

Table 4. Descriptive statistics of outcome measures: HAQ functional disability index, SF-36 physical component scale and SF-36 domains role physical and physical functioning

	HAQ: functional disability index (FDI)	SF-36: physical functioning (PF)	SF-36: role physical (RP)	SF-36: physical component scale (PCS)
Controls (*n* = *311*)				
Mean (SD)	0.35 (0.53)	76.95 (24.19)	65.18 (42.70)	44.71 (10.91)
Range	0.00–2.88	0.00–100.00	0.00–100.00	9.92–64.51
Cases (*n* = 146)				
Mean (SD)	0.46 (0.66)	71.86 (26.15)	56.68 (44.36)	42.45 (11.85)
Range	0.00–3.00	0.00–100.00	0.00–100.00	15.71–61.29
Correlation (*Pearson's R*)				
FDI	1.00	–0.77	–0.56	–0.67
PF		1.00	0.68	0.86
RP			1.00	0.84
PCS				1.00

All correlation coefficients are significant at a level of $p < 0.001$.

physical component scale (PCS) of the SF-36 were chosen as alternative outcome measures. Table 4 shows the descriptive statistics and the bivariate Pearson correlation between these concurrent outcome measures.

In the logistic model, the FDI was dichotomized at a defined cut-off so as to differentiate between mild to moderate impairment of function and functionally relevant impairment. Among the components contributing to the overall assessment of independence represented by the FDI, the greatest effect appeared to come from hygienic factors (bathing, toilet, etc.). FDI was significantly higher in older subjects, in women, and in persons with a higher body mass index (weight/height^2).

A significant effect of the fracture on FDI appeared in the first 2 years of injury (Fig. 1), where the coefficient on the indicator variable was estimated at 0.42 in the regression equation. That is, on average the FDI was 0.42 higher (on a scale of 0 to 3) among subjects with a fracture in the past 2 years than in the control group. This difference fell to 0.14 in years 3–4 and was negligible after that. The small sample size did not allow us to claim statistical significance ($p > 0.05$) after the first 2 years, but the findings suggest that a small effect may still be detectable up to years 5–6 after injury. None of the social, economic, family or other personal factors evaluated other than the social network index had a

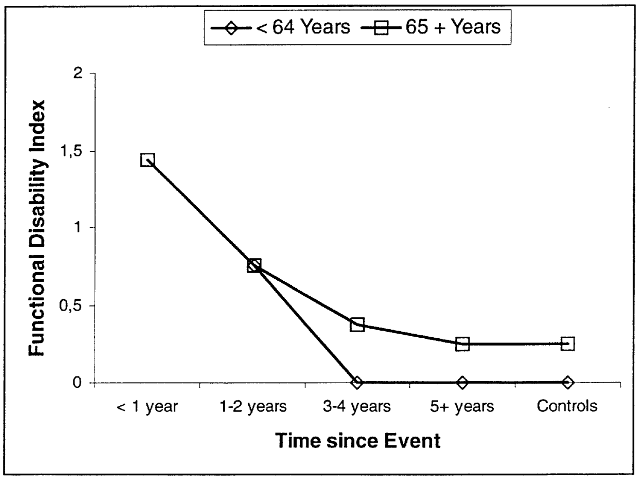

Fig. 1. Mean effect of fracture and time since fracture on Functional Disability Index. Data points relate to cases, with age-specific control values given as last data point to the right.

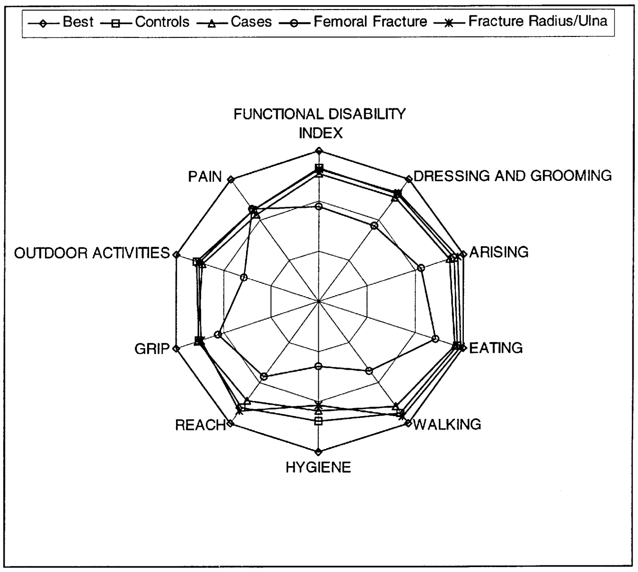

Fig. 2. Functional outcome by domains: Health Assessment Questionnaire. The distance from the center to the outer circle represents a range from 3 to 0 points.

measurable effect on FDI during the period of recovery. We were not able to show an effect from any of the surgical or rehabilitative interventions after controlling for type of fracture, age and sex.

A multidimensional assessment of the functional and health status outcome following fractures is displayed as a star chart in Figs 2 and 3. As can be seen, little difference in functional and health status loss is observed between cases and controls apart from fractures of the femur. Regarding function, all domains except pain are affected. Regarding generic health status, the domains relating to physiologic functioning and vitality were most affected.

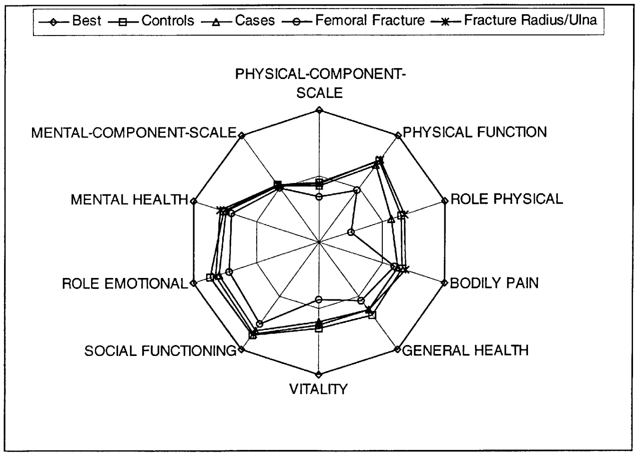

Fig. 3. Health status by domains: Medical Outcomes Study Short Form 36 (SF-36). The distance from the center to the outer circle represents a range from 0 to 100%.

Discussion

This study was designed to take advantage of an existing cohort with a well-established methodology for questionnaire administration and data management. One limitation was the need to inquire retrospectively about the occurrence of a fracture: this may introduce some recall bias in the classification since subjects may not remember exactly when their most recent fracture occurred; more importantly, it eliminates patients who died as a result of their fracture. Since the results for cases with a fracture more than 6 years previously were similar to those for controls, the first of these biases is probably not important. A separate validation study on 100 fracture cases regarding the location of their fracture as given on interview compared with medical discharge letters yielded a kappa statistic of 0.79 for side and location [15]. This is in accordance with other published studies [16,17].

Morbidity of selected study subjects may have led to non-responses. In order to minimize this potential source of bias, study subjects were offered either transportation to the study center or a home visit. Fifty invited patients declined to participate in the study for medical reasons, but only 12 of them had been classified as fracture cases based on the preceding assessment. In order to assess the effect of selective mortality, we requested information on the mortality of the selected participants for the last 13 years and were reassured to find that only 37 patients had died, none of them with a principal diagnosis of fracture. Non-responders were similar to responders regarding recorded demographic variables. Hence, it appears that morbidity and mortality as potential sources of selection bias did not play a major role.

Two controls were selected for each case and matched by age (5-year age group) and sex from the information available from their last examination. However, because 2 years had passed on average since this last examination, some controls had suffered an osteoporotic fracture of the extremity that qualified him or her as a case. They were regarded as cases, not as controls, because the functional outcome after a fracture would otherwise have been contaminated. Because women are affected more frequently by osteoporotic fractures at a higher age than men, this introduced a distortion of the gender balance within cases and controls, with more female cases and consequently fewer females in the control group. Though this would have a potential for bias in an unstratified analysis, this is not the case in multivariable adjusted regression with the forced-in variables age and sex. There is no distortion between the age structure of the groups. The mean age among cases was 66.9 years (SD 5.6 years). The mean age among controls was 66.7 years (SD 5.9 years). An alternative would have been to omit these cases from the analysis and resample the population so as to guard the power of the study. However, since a shift from controls to cases does not decrease the power in a 2:1 matching design, but rather increases the power, no resampling was done.

The small number of cases in subgroups also limited our ability to detect effects from different treatments or social situations. Few studies have used generic or specific musculoskeletal outcome measurement instruments to assess health status and functional recovery following fractures [4,18–20], although these measurement instruments are widely applied in arthritis research and in fact originated to a large extent from rheumatologic research [7,8,21].

Reliability of the applied measurement instruments was assumed, based on reported results in the literature. Validity of the application of the selected instruments to functional recovery and health status measurement following fractures was tested in several ways: applying a widely accepted generic outcomes measure (SF-36) and a well-tested musculoskeletal outcomes measure as disease-specific instrument to fracture patients in a recovery phase extending over several years after the incident appeared, *prima facie*, to be valid. Results were consistent for related outcome measures of other measurement instruments, suggesting convergent validity. Predicted poor health outcomes for stroke, comorbidity and hip fractures were confirmed by our measurement instruments. Concurrent measurement of physical functioning resulted in moderate to high correlations (Table 4). The measurement instruments were age-sensitive, were able to discriminate between cases and controls, and were especially able to discriminate between hip fracture patients and persons who had suffered a less severe fracture type (Figs 1–3). It was possible to gain insight into areas of functional impairment despite small numbers in fracture subgroups, as well as insights into the recovery over time following fractures.

The worse functional outcome among those over 65 years of age compared with the younger age group reflects the reduction in functional reserve of higher age. This decline in functional reserve is evident also for the musculoskeletal system, e.g., by the loss of bone mineral density (osteopenia and osteoporosis), osteoarthrosis or loss of muscle strength, coordination, and protective reflexes. Moreover, activities of daily living often require complex functions to which other organ systems also contribute. For example, climbing stairs requires functional reserves of the cardiovascular and respiratory systems, in addition to functional competence of the locomotor system. Walking outdoors also requires intact orientation and balance, intact cognition, and confidence to cope with the demands of our complex man-made environment (e.g., using public transport). A passive attitude towards the demands of daily life can lead to a vicious cycle of further loss of function, increasingly less exercise and a negative feedback for multiple organ systems.

Meaningful interventions should aim at breaking this vicious cycle. While the important role of activating exercises delivered by physiotherapy and ergotherapy in the early rehabilitation phase are generally accepted, our data indicate a need for a reassessment of function for a prolonged period following a fracture, with special emphasis on perceived gait disturbances. While the ability to walk is itself of high value for independent living, we hypothesize that perceived difficulties with walking could be a sensitive early warning sign and should trigger a comprehensive medical or geriatric assessment. A recent Cochrane review of fall prevention programs has demonstrated the importance of multimodal, multidisciplinary approaches for effective interventions [22].

Fractures among the elderly are also associated with an increased mortality. No precise estimate on mortality or case fatality was possible due to the predominantly retrospective study design. Over the follow-up period from 1994 to 1998 no excessive death rate in the fracture group could be identified. This may reflect the selection of healthier persons able to attend the first examination in 1994/95, and the relatively small number of persons who suffered a severe fracture between 1994 and 1998 (3 cases with femoral fractures among 50 persons with any fracture). Among fracture survivors, it appears that functional recovery takes place in multiple dimensions over a period of 3–4 years, slowing down with age and leveling off towards the age-specific average.

The mean age in our study was 66.8 years. This is considerable younger than the typical age for osteoporotic fractures in women and also in men. Our study population is not representative for the average patient suffering an osteoporotic fracture. However, the objective of the study was to study the functional outcome of fractures in an elderly population, without restricting the fractures of interest to osteoporotic fractures and without restricting the time of the primary fracture to old age. The main objective was to identify risk predictors with respect to independent living. Current knowledge supports the view that preventive measures among the elderly are more effective when provided to younger subjects with a fair functional ability. Our patient group resembles this subgroup of high potential and hence is well suited for generalization of the results to similar subgroups in the population.

The identification of osteoporosis among probands was by self-report. The reasons for an individual regarding herself or himself as osteoporotic vary among subjects. It may be related to a previous osteodensitometry, but it may also be related to the judgment of a physician based on other evidence, or may reflect only the patient's opinion. However, when comparing the age- and sex-specific prevalence rates of self-reported osteoporosis, these were similar to prevalence rates based on the population-representative osteodensitometric results from NHANES III in the USA (bone density below a *T*-score of –2.5).

Despite the limitations of our study in design and numbers, it was possible to explain more than 40% of the observed variance in FDI scores by a simple model consisting of the forced-in variables age, sex, status as case/control and perceived difficulty walking. The explained variance increased to about 50% when further significant factors were retained in the model (Table 3). The estimated effect of walking on several functional measures was comparable when asking the respondents directly about difficulty walking or using the walking subscale of the HAQ, and was independent of having suffered a fracture. Fractures other than femoral fractures by themselves played little role in an overall assessment of functional capability and health status.

Existing generic and specific musculoskeletal outcome measurement instruments allow the assessment of functional recovery and health status after fractures in an elderly population, and this assessment should be continued for several years following the incident. Difficulty walking deserves special attention, as it is associated with a more general functional disability among the elderly, whether the person has suffered a fracture or not. Further attributes of relevance for functional capacity are obesity, depression, and the number and quality of social contacts. Efforts to improve these factors, e.g., in the context of a preventive, comprehensive assessment following osteoporotic fractures, may contribute to functional independence in the elderly.

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