

Maintenance of Functioning in the Elderly

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ABSTRACT *Dramatic declines in age-specific mortality have led to large increases in the number of older people in the United States and other industrialized populations. While increased survival time is to be desired, it is important to consider the functional ability of those who survive to older ages, and whether preventive activities can lead to higher levels of functioning. Using data from the Alameda County Study, results indicating that incident chronic diseases are associated with poorer levels of physical functioning are presented. Many of the behavioral, social, and demographic risk factors that are associated with risk of chronic disease and mortality in this cohort are also associated with poorer physical functioning. Thus, interventions that reduce or delay the development of chronic diseases in the elderly may also result in higher levels of physical functioning. These same risk factors also modify the impact of chronic disease on functioning. Therefore, interventions that reduce risk factors for chronic disease may increase levels of functioning in those who survive with or without disease. Ann Epidemiol 1992;2:823-834.*

KEY WORDS: *Aging, physical function, secondary prevention, behavioral, social factors, psychosocial.*

INTRODUCTION

Increasing awareness of changes in the age structure of the population and a growing epidemiologic literature concerned with health problems of the elderly have focused attention on issues of primary and secondary prevention in the elderly. After briefly reviewing demographic trends, changes in the health status of the elderly, and associations between behavioral and social factors and mortality in the elderly, this article turns to the importance of maintaining physical functioning with aging. Using analyses from the Alameda County Study, it examines the role of chronic disease in physical functioning, and the ability of behavioral, social, and sociodemographic factors to modify the impact of chronic disease on level of physical functioning.

DEMOGRAPHIC CHANGES

Although the population of the United States has undoubtedly been growing older for the last two centuries, up until relatively recently this trend went unnoticed. Recent changes in the age structure of the population have been so striking as to have been labeled "a demographic revolution" and "the graying of America" (1, 2). Between 1960 and 1985 the population aged 65 and older increased by 71%, almost three times faster than the rate of increase for those under 65. The numbers are even more striking when those over 85 years are considered. Between 1960 and 1986 their numbers increased 199%, almost six times the rate of growth of the population as a whole (3).

As a result of these changes, in 1986 the population over 65 years old comprised

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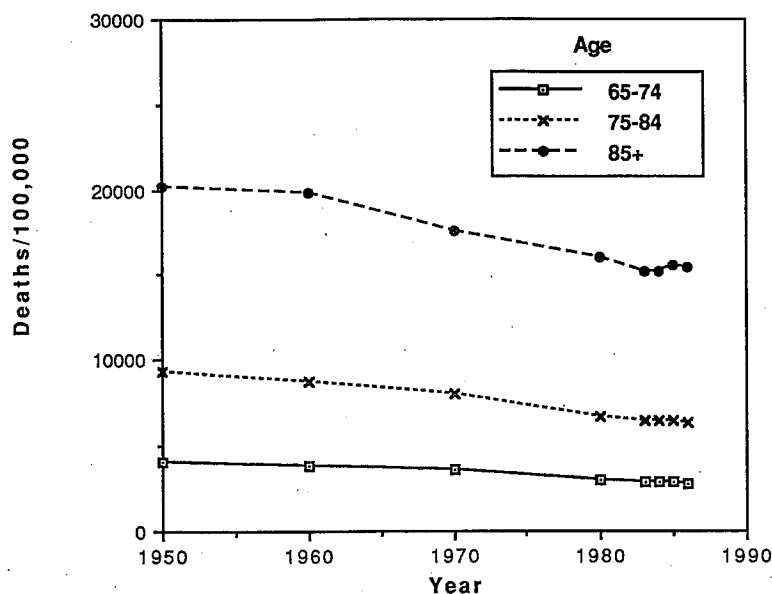


FIGURE 1 Decline in age-specific mortality. United States, 1950 to 1986. From National Center for Health Statistics (3).

more than 12% of the total population, a 50% increase since 1950. In the United States in 1987, over one-third of deaths occurred after age 80; for white women, almost 50% of deaths occurred after age 80 (4). This pattern is, of course, not restricted to the United States, but is being seen in virtually all industrialized countries. For example, Swedish figures indicate that more than 18% of the Swedish population is expected to be over 65 years old in 1990, rising to over 20% in 2020 (5).

Why has there been such a striking rise in the proportion of elderly persons in the population and what does it mean? The first question is considerably easier to answer than the second. Declines in fertility and the aging of earlier birth cohorts accompanied by increased survival at older ages are thought to be the major determinants of these changes in population age structure.

DECLINES IN AGE-SPECIFIC MORTALITY

Figure 1 shows the decline in age-specific mortality rates for the older ages in the United States from 1950-1986 (3). Mortality rates for those 65 to 74 years old declined 31% during this period, and the decline was almost 24% for those over 85 years old. Similar results were seen when the age-specific 9-year risk of death was compared in two cohorts of the Alameda County Study (6, 7) studied in 1965 and 1974 (8). It is important to note that a substantial portion of this decline in mortality rates at the older ages reflects declines in rates of death from cardiovascular and cerebrovascular causes (Figure 2). For example, for 65- to 74-year-olds, the decline in cardiovascular and cerebrovascular mortality was 93% of the overall decline in all-cause mortality rates. For those 75 to 84 years old and 85 years and older, the corresponding percentages were 87% and 67%.

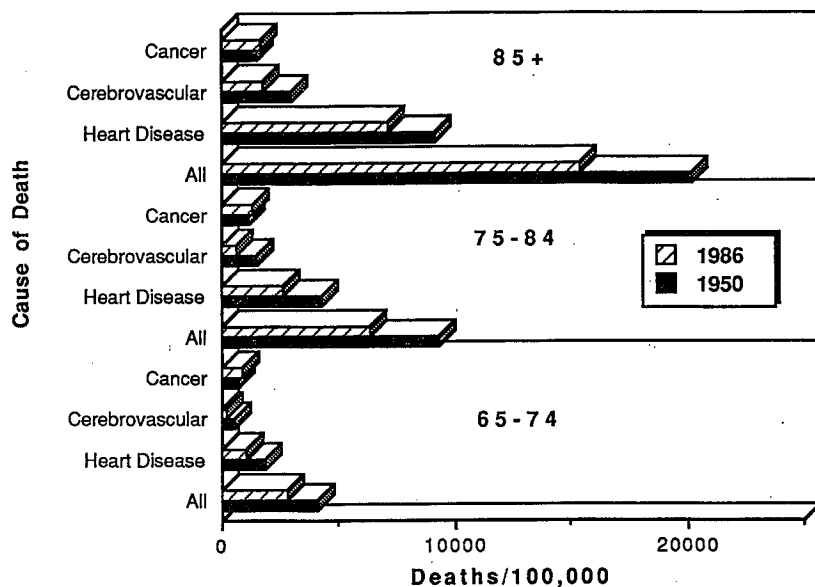


FIGURE 2 Decline in age-specific mortality by cause. United States, 1950 and 1986. From National Center for Health Statistics (3).

PREVENTION AMONG THE ELDERLY

It is instructive to examine some of the possible reasons for this decline in age and cause-specific mortality. A growing amount of evidence suggests an important role for primary and secondary prevention among the elderly (6). Contrary to earlier beliefs, often based on inadequate data, there do seem to be important associations between a variety of risk factors and the health experience of older persons.

For example, in a series of analyses using data collected as part of the Alameda County Study, a population-based epidemiologic study begun in 1965 (6, 7), a wide variety of behavioral, social, and demographic factors were shown to be importantly associated with risk of death from all causes, even in those 70 to 94 years old who were followed for 17 years (9, 10).

Figures 3 and 4 show the results of some of these analyses. All of these analyses used proportional hazard regression analyses with adjustment for a variety of covariates including the presence of a number of chronic conditions and symptoms at baseline. Those 70- to 94-year-olds who were current smokers had a 43% (95% confidence interval, 8 to 89%) higher risk of death over a 17-year follow-up period compared to those who were never smokers. Physical inactivity was associated with a 37% (95% confidence interval, 9 to 72%) higher risk; abstention or heavy consumption of alcohol, with a 39% increase (95% confidence interval, 6 to 105%); and extremes of relative weight [weight (lb)/height² (ft)] were associated with a 32% (95% confidence interval, 5 to 67%) increased risk of death.

Figure 4 shows the results of similar analyses that examined the association between a variety of social risk factors and 17-year risk of death (10). While being married ceased to convey a protective effect in the elderly, measures of social isolation and nonparticipation in groups were associated with a 20 to 30% elevation in risk. When these measures were combined using the Berkman and Syme social network index

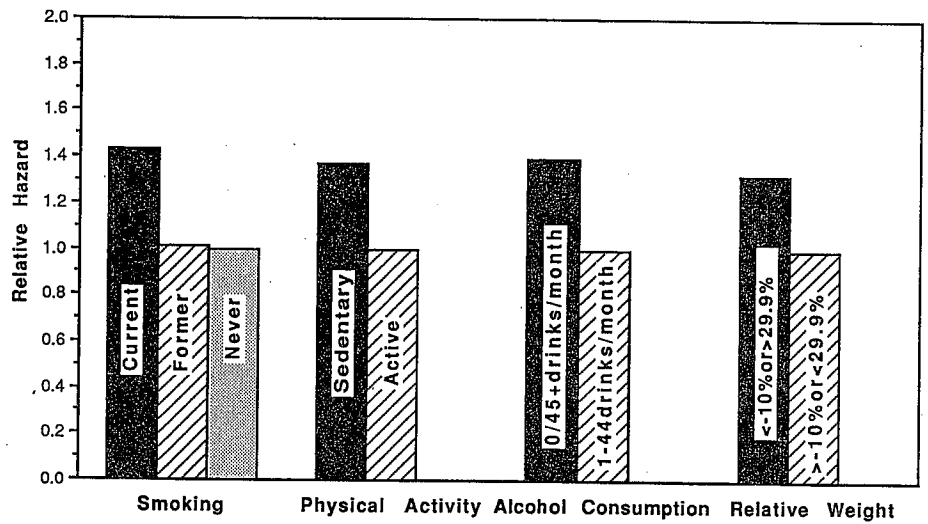


FIGURE 3 Behavioral risk factors and 17-year risk of death in 70- to 94-year-olds, Alameda County Study. From Kaplan et al. (9).

(11), those in the lowest group were at a 69% (95% confidence interval, 24 to 129%) higher risk of death compared to those in the highest group.

There is some evidence that elimination of or reduction in behavioral or social risk factors in older persons may also convey health advantages. For example, in the Alameda County Study, 50- to 89-year-old smokers who quit smoking in one 9-year period evidenced a decreased risk of death during a subsequent 9-year period when compared to those who continued to smoke (8) (Table 1). Participants were classified by their smoking status in 1965 and, 9 years later, in 1974, and risk of death was examined for the next 9-year period, 1974 to 1983. Not surprisingly, the never smokers did best, followed by those who had previously smoked but had quit by 1965. What

FIGURE 4 Social risk factors and 17-year risk of death in 70- to 94-year-olds, Alameda County Study. From Seeman et al. (10).

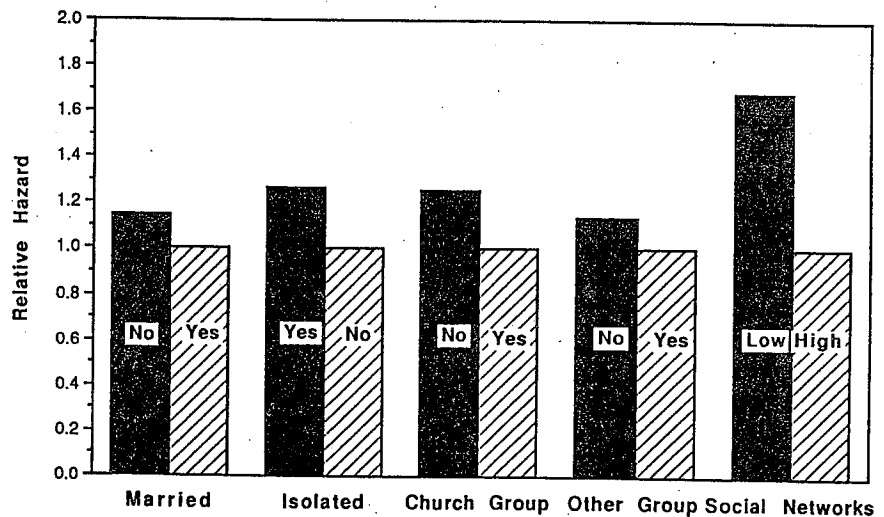


TABLE 1 Association between smoking change (1965-1974) and 9-year (1974-1983) all-cause mortality in those 50 to 89 years old in 1965, Alameda County Study

Smoking status	Relative hazard	95% Confidence interval
Never	1.00	—
Quit before 1965	1.06	0.79-1.42
Quit 1965-1974	1.33	0.98-1.82
Current	1.76	1.35-2.31

From Kaplan and Haan (8).

is most important is the decreased risk for those who quit smoking during 1965 to 1974 when compared to those who continued to smoke. In similar analyses, increases in physical activity were also associated with subsequent decreases in mortality risk (8).

These results, along with recent results from Honolulu, Framingham, Rancho Bernardo, and other studies (12-16) indicate that there may be important potential for preventive activities among older persons. While the Alameda County results have focused on mortality, other more recent analyses have examined disease incidence or case fatality. For example, Benfante and colleagues showed that smoking and serum cholesterol levels were associated with 12-year incidence of coronary heart disease in 65- to 74-year-old participants in the Honolulu Heart Study (12, 13). In analyses using the Coronary Artery Surgery Study registry, quitting smoking was also associated with decreased risk of death in 65- to 83-year-old men and women who had angiographically documented evidence of coronary artery disease (17). Thus, there appears to be a role for prevention in older persons across the spectrum of disease presentation. However, for the most part, these conclusions are based on observational studies, and controlled interventions need to be conducted in order to increase confidence in these conclusions.

ADDING LIFE TO YEARS

While the data are not adequate to demonstrate to what extent changes in these behavioral and social risk factors, and others, can account for the declines in mortality rates at older ages, or to pinpoint the additional role of specific medical interventions, one thing is clear—there are substantially more older persons around than ever before. To these older persons and other members of society, perhaps the most critical issue has become the quality of life during these extended years. As gerontologists are fond of saying, "It is important to add life to years, not simply years to life."

Critical to such a goal is maintenance of functional ability in the later years. Functional ability, of course, covers a wide spectrum of physiologic, physical, social, cognitive, and affective domains. Maintenance of physical functioning is particularly important and will be the focus of the remainder of this article. Physical functioning is important because it provides a substrate for many of the activities that we consider essential to independent living. In addition, we know the most about the predictors of physical functioning. Finally, many measures of physical functioning have substantial cognitive, social, and motivational components.

Physical functioning can be measured in many ways, most of which involve measures of various activities of daily living or basic tasks that need to be carried out during the ordinary day (18). Recently there has also been renewed interest in direct

TABLE 2 1965 predictors of 1984 functional health status in 65- to 89-year-olds, Alameda County Study

Predictors	β^a	P
Age	-0.34	.0001
Sex (male/female)	-0.63	NS
Race (nonblack/black)	-4.26	.0005
Chronic conditions (0/1+)	-0.32	NS
Symptoms (0/1+)	-1.82	.04
Disability (0/1+)	-2.78	.008
Physical activity index	0.30	.008
Current smoker (yes/no)	2.22	.006
Moderate relative weight (yes/no)	-2.37	.014
Hypertension (yes/no)	3.25	.01
Family income index	1.39	.004
Marital status (married/not married)	-3.00	.0014

From Guralnik (21).

^a Multiple regression analyses with simultaneous adjustment for all variables.

measurement of physical performance of the elderly (19). Generally speaking, the prevalence of difficulties carrying out these activities is very low in middle age and rises very quickly after the ages of 75 to 80. In the East Boston cohort of the Established Populations for Epidemiologic Studies of the Elderly (EPESE), for example, the prevalence of reported trouble bathing was roughly 5% for 65- to 69-year-old men and women, but rose to 28% for men and 44% for women 85 years or older (20).

LONG-TERM PREDICTORS OF FUNCTIONING

Few studies have examined long-term predictors of functional ability. In order to address this lack, Guralnik (21) examined the ability of variables measured in 1965 to predict physical functioning assessed in 1984 in members of the Alameda County Study who were then 65 to 89 years old (Table 2).

The measure of physical functioning was a broad one, covering the spectrum of functioning from limitations in activities of daily living to participation in aerobic activities, with many intermediate items. Participants were 65 to 89 years old in 1984, and risk factors were measured 19 years earlier. Lower levels of physical functioning were associated with being female, being black, having chronic disease symptoms, current smoking, being underweight or extremely overweight, having a lower family income adjusted for family size, being unmarried, and having lower levels of leisure-time physical activity. Self-reported hypertension was also a strong predictor. Altogether, the regression model accounted for approximately 30% of the variance in physical function (21). In another long-term study, using a 25-year follow-up of the Charleston Heart Study, there was also evidence for long-term prediction of physical functioning. Those who were black, hypertensive, obese, and smoked evidenced lower levels of functioning (22).

CHRONIC CONDITIONS AND FUNCTIONING

Why should these variables be related to physical functioning measured 19 years later? A reasonable hypothesis is that these variables are risk factors for chronic diseases and are associated with earlier development of these diseases, which in turn are associated with impaired physical functioning.

TABLE 3 Age- and sex-adjusted association (odds ratio) between individual incident conditions and incident functional health problems, Alameda County Study, 1965-1974

Conditions	Self-care problems		Mobility problems	
	Odds ratio	95% CI	Odds ratio	95% CI
Stroke	6.65	3.44-12.86	6.15	3.39-11.16
Shortness of breath	4.84	2.68- 8.71	5.61	3.55- 8.86
Heart trouble	3.08	1.76- 5.41	5.38	3.53- 8.18
Joint stiffness	4.55	2.32- 8.91	5.59	3.60- 8.71
Chest pain	2.83	1.47- 5.47	4.26	2.62- 6.92
Constant cough	4.06	1.87- 8.83	4.04	2.13- 7.65
Diabetes	2.21	0.91- 5.39	3.22	1.70- 6.08
Back pain	2.06	1.04- 4.10	2.63	1.66- 4.16
Leg cramps	2.24	1.19- 4.22	2.62	1.66- 4.14
Ulcer	1.49	0.45- 4.99	2.46	1.14- 5.32
Arthritis	1.67	0.81- 3.45	1.86	1.14- 3.03
High blood pressure	1.12	0.55- 2.30	1.76	1.09- 2.84
Chronic bronchitis	2.69	1.10- 6.61	1.33	0.61- 2.92
Trouble hearing	2.45	1.32- 4.56	2.11	1.32- 3.39
Trouble seeing	3.00	1.62- 5.54	3.27	2.09- 5.14

To examine this in more detail, the association between incident chronic disease and the development of new problems in physical functioning in the Alameda County Study was assessed (Table 3). The participants included approximately 1200 men and women who were 50 to 86 years old in 1965 and who participated in a follow-up study in 1974. Thus, entry into these analyses was conditional on being alive 9 years after entry into the study. Two outcomes were examined: "trouble dressing, feeding, or moving," and "trouble climbing stairs or getting outdoors." Each of these had to be reported as existing for at least 6 months. Each analysis was restricted to persons who did not report a particular chronic disease or functional problem at baseline. Because it is unlikely that the health problem resulted from the problems in physical functioning, the simultaneous analysis of incident functional problems and incident chronic health problems is defensible. However, verification of the causal directions suggested by these analyses will require nonsimultaneous measurement including information on time of incident disease and development of functional impairment.

Incident chronic health conditions are strongly associated with the risk of developing either one of these physical function outcomes. Not surprisingly, incident stroke had the strongest association with both of the outcomes. However, stroke is relatively rare, and when simple univariate population-attributable risk calculations were carried out (23), the most important incident chronic conditions for mobility limitations were joint problems (45.6%), trouble breathing or shortness of breath (32.6%), heart trouble (32.5%), and chest pain (21.7%).

In the same analyses, a number of other factors were also found to be associated with the risk of developing a problem in physical functioning. In separate multiple logistic analyses, adjusted for age and sex, current smokers were at increased risk of incident functional problems, as were those who were depressed, who had low income, and who were obese, physically inactive, or socially isolated (Table 4).

Given that chronic disease is strongly associated with problems in functioning, are there other factors that might modify this association? This is an important question, because it is implausible that it will be possible to eliminate all chronic diseases or to delay them until just before death. The search for such factors suggests a potentially important shift in focus to the prevention of disease-associated disability.

TABLE 4 Age- and sex-adjusted association (odds ratio) between 1965 behavioral, social, and psychological risk factors and incident problems in functioning (1965-1974), Alameda County Study, 50 to 89 years in 1965

Risk factors	Self-care problems		Mobility problems	
	Odds ratio	95% CI	Odds ratio	95% CI
Current smoking	1.69	0.99- 2.88	1.83	1.29-2.60
Depression	3.07	1.78- 5.30	3.67	2.52-5.35
Social isolation	1.68	0.96- 2.96	1.22	0.82-1.80
Inadequate income	1.84	0.77- 4.41	2.68	1.57-4.61
>30% overweight	1.45	0.75- 2.80	1.85	1.20-2.85
Sedentary	5.25	1.25-22.07	3.03	1.54-5.96

Further analyses from the Alameda County Study shed some light on this possibility. In these analyses several incident conditions were grouped together in order to have adequate power. In order to enter the analysis, subjects had to have participated in the 1974 follow-up; not have reported a history of stroke, heart trouble, or arthritis at baseline; be 50 to 93 years old at follow-up; and not have any mobility limitation at the baseline examination. An index was then constructed based on the number of these three conditions, which were newly reported at follow-up. Sixty-nine percent did not report any incident conditions, 28% reported one, and 3% reported two or three incident conditions. There was a strong relationship between these incident conditions and incident mobility limitations. Those who reported one incident condition were at 2.5 times (95% confidence interval, 1.60 to 3.94) the risk of becoming functionally impaired as those who reported none, and those with two to three incident conditions were at 14.3 times the risk (95% confidence interval, 7.44 to 27.44) of those with none (data not shown).

The next step in the analyses was to examine whether risk factors that were in themselves associated with levels of physical functioning might also modify the association between chronic conditions and problems in physical functioning. These analyses were, accordingly, restricted to those study participants with at least one incident condition out of the three mentioned above (Table 5). Multiple logistic analyses were used to examine the ability of the factors smoking, income, and depression to predict incident mobility limitations in those with incident disease. The results are quite strong. Being a current smoker, having an inadequate level of family income adjusted for family size, and being depressed were all associated with substantially elevated risks of developing a mobility limitation in these persons with incident chronic conditions. Thus, chronic disease does not carry with it an automatic increase in risk of impaired

TABLE 5 Age- and sex-adjusted association (odds ratio) between 1965 risk factors and 1965-1974 incident mobility problems around those with 1965-1974 incident heart trouble, stroke, or arthritis, Alameda County Study

Risk factors	Mobility problems	
	Odds ratio	95% CI
Current smoking	2.87	1.58-5.24
Depression	1.81	0.90-3.65
Inadequate income	2.43	0.99-5.96

TABLE 6 Association between demographic characteristics, chronic conditions, and health practices and 19-year functional status (high level of function, low/moderate level of function, deceased)^a

	High level of function vs. deceased		High level of function vs. low/moderate level of function	
	Odds ratio	95% CI	Odds ratio	95% CI
Model 1				
Sex (male/female)	0.5	0.3- 0.8	1.2	0.7- 1.9
Race (nonblack/black)	4.1	1.4-12.4	3.1	1.1- 9.3
Income (adequate/marginal or inadequate)	4.9	3.0- 8.2	3.1	1.4-10.2
Model 2				
High blood pressure (no/yes)	6.7	1.9-23.8	4.1	1.2-14.1
Arthritis (no/yes)	2.4	1.1- 5.3	3.0	1.4- 6.5
Back pain (no/yes)	1.9	1.0- 3.7	2.0	1.1- 3.6
Model 3				
Smoking (not current/current)	6.1	3.3- 8.3	2.2	1.3- 3.8
Relative weight (moderate/other)	2.6	1.1- 6.1	2.4	1.1- 5.1
Alcohol consumption (1-60 drinks/none)	3.1	1.5- 6.5	2.2	1.1- 4.4

From Guralnik and Kaplan (26).

^a Odds ratios adjusted for age, race, sex, baseline functional status, and all variables in model.

functioning; rather, there seem to be potential points of intervention that might lessen the impact of disease on functioning. It is, of course, possible that these results simply indicate that smoking, low income, and depression are associated with more severe disease, which would be expected to result in more impairment in physical functioning. Smoking, low income, and depression might also be associated with an increase in the number of significant comorbidities present that might be expected to worsen the outcome. Much more work needs to be done with a careful examination of clinical indicators of severity and prognosis, and with the methodology of controlled trials to confirm the impact of these factors on the development of chronic disease-related disability.

Finally, there is the interesting issue of maintenance of high-level physical functioning in the elderly. A substantial proportion of the elderly population do not evidence functional impairments, are vigorous and alert, and do not seem to be bogged down by an accretion of major chronic diseases and ailments. Using data from the Alameda County Study the factors associated with high levels of physical functioning in those over 65 years old were investigated (24).

In these analyses the ability of social and behavioral factors measured in 1965 to predict high levels of functioning in 1984, 19 years later, was examined. The analyses were carried out using polytomous logistic regression, which allows one to examine the association between a risk factor and several nonoverlapping outcomes (25). Three outcomes were used: having died during the 19-year follow-up period, having survived but in the bottom 80% of the distribution of physical functioning, and having survived and being in the top 20% of the distribution. All analyses adjusted for age, race, sex, and baseline level of physical functioning.

Table 6 presents the association between a variety of 1965 risk factors and surviving with high levels of function versus being dead, as well as surviving with high levels of function versus surviving with medium or low levels of function. Generally, the picture

looks quite similar whether one is considering the odds of surviving with high levels of function versus dying or surviving with high levels of function versus low levels of function. The exception is for females, where the survival advantage is accompanied by a disadvantage when high levels versus low levels of function among survivors are considered.

Thus, the results indicate that the same risk factors are predictive whether one is considering risk of death, surviving with low physical function, or surviving with high levels of physical function. In other words, being a smoker decreases the chances of surviving at all, and also decreases the chances of surviving with high levels of function. These results suggest that those who survive with high levels of function are simply those with better risk-factor profiles earlier in life.

CONCLUSIONS

1. There are greater and greater proportions of older persons in the population.
2. Physical functioning, necessary for independent living in the elderly, seems to be strongly associated with chronic disease.
3. Declines in age and cause-specific mortality at the older ages indicate that the relationship between age and disease is not fixed.
4. A variety of factors appear to be associated with chronic disease incidence and mortality in older persons.
5. Factors that are associated with decreased incidence of chronic disease and mortality may also be associated with a higher level of physical functioning and also with reduced deficits in functioning among those who do develop chronic diseases.

These conclusions are, for the most part, based on small numbers of studies, and much more work needs to be done. Analyses of existing data can help to flesh out the role of risk factors among older persons. Ongoing studies of the elderly using techniques such as noninvasive imaging will help to understand the role of risk factors in late-stage subclinical disease among the elderly. A great deal of work examining the role of risk factors in the cognitive, social, and psychological aspects of physical functioning still remains to be done. More attention needs to be paid to the role of primary and secondary prevention in other diseases that are importantly related to physical and mental functioning in older persons such as osteoarthritis, osteoporosis, incontinence, diabetes, dementia, visual and hearing disorders, gait disorders, and the general syndrome of frailty and "homeostenosis" (26). We need to understand more about the specific pathophysiologic processes that link disease to functioning, and the behavioral, social and psychological processes that temper the consequences of these processes. Finally, we need to acknowledge that problems in functional impairment are often reversible. In one national study, 35% of those older persons with five to six problems in activities of daily living and who survived for 2 years improved in functioning over that 2-year period (27). Very little is known about the factors associated with improvement or worsening in function.

Chronic degenerative diseases used to be seen as inevitable consequences of aging, but we now believe that such a position masks the tremendous potential for elimination or delay of these diseases. The notion that old age is necessarily accompanied by progressive, irreversible declines in physical and mental function needs to be similarly challenged in order to truly add "life to years."

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