The Dynamics of Disability and Functional Change in an Elderly Cohort: Results from the Alameda County Study

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Objective: To examine changes in functional status over time by age, gender, and ethnicity in a representative sample of older persons.
Design: Six-year prospective cohort study.
Setting: Alameda County, California.
Participants: 508 persons 65 years old and older at baseline in 1984.
Main Outcome Measures: Activities of daily living (ADL) dependence, mobility impairment, and functioning on an 18-item scale.
Results: The prevalence of ADL dependence and mobility impairment at baseline increased with age, while function decreased. Particularly striking differences occurred for those 80 and older. Changes in function over the 6-year follow-up showed a similar pattern. While death rates for males were higher, females had poorer initial functioning, and surviving females declined more than surviving males. The incidence of ADL dependence and mobility impairment during follow-up was similar for males and females, although females survived longer with incident disability than did males. Blacks had poorer baseline functioning, more ADL dependence and mobility impairment, and declined more than non-Blacks during follow-up. Some of the baseline difference in function between Blacks and non-Blacks was due to higher rates of chronic illness and co-morbidity. In spite of the general downward trend in functioning over the 6 years, 13% of the males and 20% of the females improved.
Conclusion: Age-related changes in function for older persons are complex and result in much heterogeneity. Clarifying the reasons for such heterogeneity is an important and challenging area of research. **J Am Geriatr Soc 40:799–806, 1992**

The proportion of Americans 65 years old and older has increased from only 4% of the total population in 1900 to over 12% of the population today; in numbers the growth has been from 3 to 30 million.[1] Decreasing mortality rates for the elderly, especially since 1950, are partly responsible for such rapid growth.[2] While the reasons for such increased survival are complex and not completely understood, the result has been a need for increased attention to the health of older persons.

From an individual standpoint, physical functioning is basic to maintaining independence and participating fully in family and community activities. From a community standpoint physical functioning is important because it affects health care service needs and health care costs. The changes in functional ability that frequently accompany aging are therefore a major public health problem.

Few studies have attempted to describe changes in physical function in a representative sample of older persons over time. Harris et al,[3] focusing on functional changes over a 2-year period for those 80 and over, reported that 50% of the females and 58% of the males who had been physically able in 1984 were either dead or disabled 2 years later. Manton[4] used data from the 1982 and 1984 National Long Term Care Surveys to examine both decline and improvement in functional status for those 65 and older over a 2-year period. While there was a strong relationship between advancing age and increasing disability, and a general decline in functioning over the 2-year period, there were persons at all ages who improved. Women had higher rates of disabilities than did men. The four Established Populations for Epidemiologic Studies of the Elderly (EPESE) studies now underway are designed to measure functional changes in older persons over time.[5,6] At baseline the functional ability of women was poorer than that of men and that of Blacks poorer than Whites on a set of ADL, instrumental activities of daily living (IADL), physical performance, and mobility measures.

If generalizations are to be made about functional change in the 65 and older population, studies must include representative samples of older persons, as did the six just mentioned. Other studies of physical function in older persons have excluded one or more of the following: the sick or disabled, females, ethnic minorities, very old persons, those who were institutionalized during follow-up, or those who moved away.[7–13] While such exclusions may make sense for a particular research question, issues of sampling bias would need to be addressed before the findings from these studies could be generalized to all older persons.

The study described in this paper examines 6-year changes in functional status in persons 65–99 years old who were original members of the population based Alameda County Study sample.[14] Comparisons are made by age, gender, and ethnicity. Previously reported analyses examined long-term predictors of physical functioning in this group.[15] The present analyses examine baseline differences and changes in physical function over a 6-year period.

METHODS

Study Population The population used in this analysis is a subsample of the Human Population

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Laboratory's Alameda County study. Detailed design and sampling procedures are reported elsewhere.[14,16] The original cohort of 6,928 persons was selected to represent the adult non-institutionalized population of Alameda County in 1965 and included a response rate of 86%. Surviving members were reinterviewed in 1974, and a representative 50% subsample was interviewed for a third time in 1983.

In 1984 a special follow-up was undertaken with the aim of looking in some detail at functional abilities among the older members of this cohort.[15] The designated sample consisted of the 580 respondents who were 65 years old or older in 1984 and who had been interviewed in 1965, 1974, and 1983. Of that group, 30 died before the field work could be completed, 12 could not be located, and another 30 declined to be interviewed. Completed interviews were obtained with the remaining 508. In 1990 we attempted to recontact this sample to measure changes in functional status over the intervening 6 years. At that time there were 381 members of the 1984 cohort for whom there was no confirmation of death. Of these, all but five were located in 1990, and interviews were completed with 356 (20 declined to be interviewed.) The total proportion of the original 508 who could not be located or who declined to be interviewed was only 4.9%. There were 62 Blacks among the original 508 subjects, and 42 among the surviving 356.

For this study, "baseline" refers to information collected in the 1984 interview or to items like education previously collected in 1983. The baseline and mortality analyses presented here include all of the 508 persons interviewed in 1984; functional change analysis and incidence calculations are based upon the 356 survivors interviewed in both 1984 and 1990. Nursing home residents (15 of the 356 in 1990) were included. Four persons who declined to give their ethnicity are omitted from the Black/non-Black comparisons. Proxy respondents (nearly always spouses or adult children) numbered 35 in 1984 and 38 in 1990.

Mortality Deaths were ascertained through computer-matching against the California Master Death Index. This information was supplemented with mortality data gathered in the tracing operations conducted as part of the 1984 and 1990 follow-up interviews. Confirmation of death was based upon death certificates. The five persons who could not be located were assumed to be still alive.

ADL Dependence and Mobility Impairment ADL dependence was defined as having at least some difficulty with one or more of seven items: bathing, eating, dressing, using the toilet, walking, transferring from bed to chair, and grooming.[11,17] Mobility impairment was defined as needing help on either of two items: walking 1/2 mile or climbing a flight of stairs.[18]

Function Scale To measure more subtle changes in function over time, a scale was developed that includes ADLs, IADLs, physical mobility, physical performance, and ability to get around. All measures were based upon self-report. The specific items included the ADL and mobility measures described above plus three IADL items (cooking, shopping, and housework),[19] five Nagi physical performance items (push/pull a large object, crouching/kneeling, lifting a 10-pound weight, lifting arms over the head, and picking up small objects),[20] and one item asking how much of a problem it was getting to places where the person wanted to go. The scale differs from the one used previously to analyze long-term predictors of 1984 physical functioning in this cohort by excluding reports of gardening and exercising while including the two items of lifting the arms over the head and picking up small objects.[15]

The 18 items making up the scale were scored as follows. The ADL and physical performance measures were scored from 0 (cannot do or need help to do) to 4 (have no difficulty doing). Intermediate scores of 1–3 were based upon level of difficulty in doing the activity (a lot, some, a little). The three IADL items were scored 0 (could not do any without help), 2 (able to do some but not all), or 4 (could do all without help). The item eliciting how much of a problem it was getting where one wanted to go was scored 0 (do not go out or a big problem doing so), 2 (a little problem), or 4 (no problem). The two mobility items were scored either 0 (need help to do) or 4 (able to do without help). The 18 items were summed; the resulting scale had a maximum theoretical value of 72 and a minimum of 0. Higher scores indicate better functioning. For 1990 the scale had a mean of 62.3, with a standard deviation of 14.9 and a range of 0–72. The scale obtained an excellent internal consistency of .94 (standardized Cronbach's alpha). Scale attributes for 1984 were similar to those for 1990.

Analysis We first examined the demographic and health characteristics of our sample. Then we looked at various demographic subgroups of the sample in terms of baseline ADL dependence, mobility impairment, mortality, and change in function between baseline and follow-up using percentage differences and analysis of variance tests for mean differences. Next, we used chi-square tests for differences in proportions and Cox proportional hazards models[21,22] (which take time from year of study entry to year of death into account) to examine the role of baseline ADL dependence and mobility impairment in predicting follow-up status controlling for age and gender. We also used Cox proportional hazards models to compare separate mortality risks for males and females associated with ADL dependence or mobility impairment.

Finally, we used multiple regression to explore possible reasons for the poorer functioning and disability rates found for Blacks compared with non-Blacks both at baseline and during follow-up. Each outcome was analyzed with five models. The first examined Black and non-Black differences only. The second added demographic controls (age, gender, and marital status). The third added the two socioeconomic status (SES) variables of household income and years of education. The fourth model added an index of behavioral and social risk factors in which respondents were given one point for each of the following: moderate use of alcohol, moderate weight, not currently smoking, exercises enough to work up a sweat, goes out 4 or more days a week, and belongs to at least one non-church group.

TABLE 1. SAMPLE CHARACTERISTICS IN 1984 STRATIFIED BY GENDER

Characteristic	Total (n = 508) %	Males (n = 212) %	Females (n = 296) %
Age groupings			
65–69	36	39	34
70–79	46	48	45
80+	18	13	21
Ethnicity (Black)	12	10	14
High school grad or more	62	67	58
Employed full or part time	13	19	9
Marital Status			
Married	70	89	57
Widowed	23	8	34
Other	7	4	9
Lives alone	27	13	36
Has arthritis	62	57	65
Has high blood pressure	38	31	43
Has poor or fair hearing	28	36	22
ADL dependent (one or more)	14	10	17
Perceived health excellent or good	73	77	70

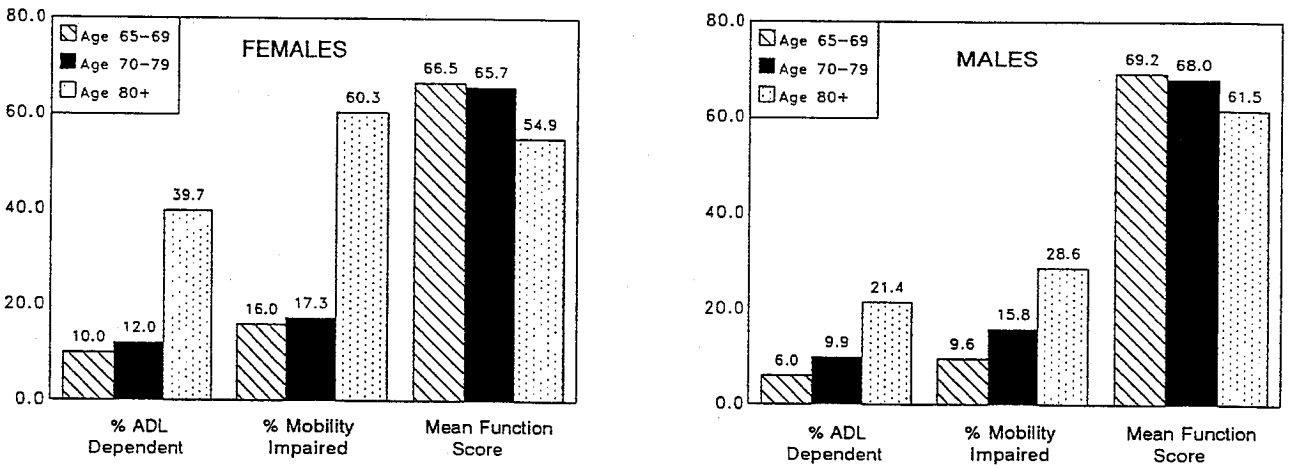

FIGURE 1. Baseline functional status by gender and age.

For the fifth model we added an index of the number of the following prevalent chronic conditions: arthritis, asthma, bronchitis, cancer, diabetes, emphysema, heart attack, high blood pressure, and stroke.

RESULTS

Cross-Sectional Analysis Table 1 presents basic demographic and health data for the study sample in 1984. Combining males and females, persons 65–69 years old made up 36% of the sample, those 70–79 constituted 46%, and those 80 and older were 18%. Women made up 58%. Twelve percent of those interviewed in 1984 were Black; there were only 14 Asian, Hispanic, or other ethnic minorities, so we included them with Whites in the non-Black category.

A much higher percentage of females than males in the study sample were widowed and lived alone. The most prevalent chronic conditions reported were arthritis, high blood pressure, and hearing problems. Ten percent of the males and 17% of the females reported at least one ADL dependency at baseline.

Figure 1 presents ADL dependence, mobility impairment, and mean function score at baseline by age and gender. While there is increasing prevalence of ADL dependence and mobility impairment with increasing age, the rates increase sharply for those 80 years old and older for both males and females. For example, the proportion of females reporting mobility impairment is 16.0% for those 65–69, and 17.3% for those 70–79, but it is 60.3% for those 80 years old and older. For males the proportion reporting mobility impairment is 9.6% for those 65–69, 15.8% for those 70–79, and 28.6% for those 80 and older. This pattern of increasing disability with advancing age plus a sharp increase in those 80 and older is also captured in the change in the mean function score. Figure 1 further reveals that the females have higher ADL dependence, mobility impairment, and lower function scores in every age category than do the males.

Figure 2 compares Blacks with non-Blacks on the same variables as Figure 1. For both males and females, Blacks had higher rates of ADL dependence and mobility impairment as well as lower function scores. We did not calculate age-specific comparisons because there were too few Blacks in the sample.

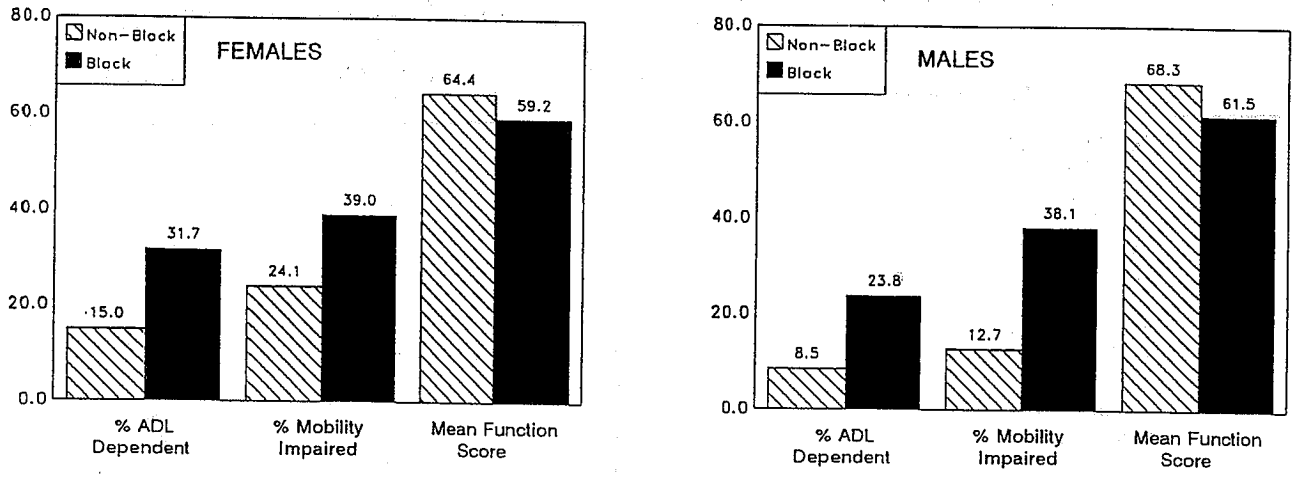

FIGURE 2. Baseline functional status by gender and ethnicity.

TABLE 2. AGE/GENDER-SPECIFIC AND AGE/GENDER-ADJUSTED MORTALITY AND CHANGE IN FUNCTION

	All Persons		Survivors: Function Change 1984–1990				
		Died		Declined	Same	Improved	
	n	%	*n*	%	%	%	Mean Change
All	508	25	356	56	27	17	−5.7
Males	212	28*	147	50	37	13	−4.9
Females	296	23*	209	60	20	20	−6.1
Blacks	62	28**	42	63	21	16	−7.9
Non-Blacks	442	24**	312	55	28	17	−5.4
Males							
65–69	83	18	64	52	30	19	−4.5
70–79	101	22	75	44	47	9	−4.7
80+	28	64	8	38	38	25	−10.0
Females							
65–69	100	14	82	54	22	24	−3.4
70–79	133	20	98	61	18	20	−6.0
80+	63	51	29	79	10	10	−14.4

Four persons who declined to give their ethnicity are omitted from the Black/Non-Black comparisons.
** Age adjusted by direct method.*
*** Age and gender adjusted by direct method.*

Longitudinal Analysis Table 2 presents mortality data and changes in function score for those who survived to the end of the 6-year follow-up. "Declined" means the person's function score in 1990 was lower than it was in 1984, "same" means there was no change, while "improved" means the 1990 score was higher. The results show that mortality rates were higher for males in all three age categories, while among survivors, more females than males declined in function. Interestingly, a higher percentage of surviving females also improved, while more surviving males remained unchanged in function than did females. Blacks were more likely to die than non-Blacks during the follow-up period, and Black survivors were more likely to decline. Indicative of the diversity typically found among the elderly is the finding that 13% of the males and 20% of the females improved in functioning during the 6 years of follow-up. Another larger group remained the same.

Comparing mean changes in the function score during follow-up for the different groups in Table 2 indicates that females declined more than males, Blacks more than non-Blacks, and older persons more than younger for both males and females. We tested these mean changes in function for statistical significance using one-way analysis of variance. Only the mean change by age for females was statistically significant ($f = 9.47$, $P < 0.0001$).

Changes in individual status from 1984 to 1990 for ADL dependence and mobility impairment are presented in Table 3. Percentages are calculated separately for the mortality ($n = 508$) and survival ($n = 356$) analyses. The most likely outcomes for those who were ADL independent or mobility independent were to remain alive and independent. Less than 20% in each of these groups died. Of the survivors, only 16% of those initially ADL independent became dependent, while 84% remained independent. For those survivors initially mobility independent, 24% became impaired while 76% remained independent. The most likely outcome for those initially ADL dependent or mobility impaired was death; for those who survived, the most likely outcome was to remain dependent or impaired. Thirteen percent of the survivors initially dependent at baseline and 23% of those initially mobility impaired recovered function by the end of 6 years. All the

TABLE 3. TOTAL SAMPLE MORTALITY DURING FOLLOW-UP AND SURVIVOR CHANGE IN DEPENDENCE/IMPAIRMENT BY BASELINE STATUS

1984 Baseline Status	Total Sample ($n = 508$)	1990 Survivors ($n = 356$)
	% Dying during Follow-up	*% Dependent in 1990*
ADL independent	19	16
ADL dependent	64	87
	($\chi^2 = 67.7$*)	($\chi^2 = 67.9$*)
	% Dying during Follow-up	*% Impaired in 1990*
Mobility independent	17	24
Mobility impaired	53	77
	($\chi^2 = 58.9$*)	($\chi^2 = 53.0$*)

* $P < 0.001$ *for chi-square with one degree of freedom.*

TABLE 4. 1990 INCIDENCE OF ADL DEPENDENCE AND MOBILITY IMPAIRMENT BY AGE, GENDER, AND ETHNICITY FOR SURVIVORS NOT DEPENDENT OR IMPAIRED AT BASELINE IN 1984

Group	No. Not ADL Dependent 1984	ADL Dependent 1990 (%)	No. Not Mobility Impaired 1984	Mobility Impaired 1990 (%)
All	333	16	309	24
Males	142	15	135	22
65–69	62	13	59	20
70–79	72	15	68	21
80+	8	25	8	38
Females	191	16	174	26
65–69	75	8	70	24
70–79	93	16	88	24
80+	23	44	16	44
Blacks*	36	28	33	27
Males	13	46	11	36
Females	23	17	22	23
Non-Blacks*	295	14	274	23
Males	127	10	122	20
Females	168	16	152	26

* *Two persons who declined to give their ethnicity are omitted from the Black/Non-Black comparisons.*

relationships noted in Table 3 were highly statistically significant.

Using the Cox proportional hazards method we examined the mortality risks associated with baseline ADL dependence and mobility impairment, adjusting for age and gender (not shown). These analyses showed that those who were ADL dependent at baseline had 3.4 times the mortality risk of those who were ADL independent (95 percent confidence interval = 2.2–5.0). The mortality risk for those mobility impaired at baseline was 2.8 times those not impaired (95 percent confidence interval = 1.9–4.2). For the 12% who were dependent on both measures at baseline, the mortality risk was 4.5 times the risk for those independent on both measures (95 percent confidence interval = 2.9–6.8).

Table 4 focuses on survivors and provides additional information on changes in function by presenting incident ADL dependence and incident mobility impairment by age, gender, and ethnicity. Incidence is defined here as a report of disability at follow-up among those who had not reported the disability at baseline. Persons with recurrent ADL dependence or mobility impairment who were temporarily independent or unimpaired at baseline are thus included.

Comparing incidence rates among the three age groups for males and females combined reveals the same sharp increase in dependence and impairment for those 80 and over as seen in Figure 1 for baseline dependence and impairment.

The percentage of females who were not ADL dependent or mobility impaired in 1984 and who became dependent in that same category, however, is similar to the percentage of males who became dependent or impaired during the same period (16% vs 15% for incident ADL dependence and 26% vs 22% for incident mobility impairment). Females appear to have higher rates of ADL dependence and mobility impairment only at 80 years old and older, although these differences are not statistically significant.

The similarity between males and females in terms of incidence of dependence and impairment contrasts with the higher prevalence rates of dependence and impairment for females seen in Figure 1 and the greater decline in function for female survivors seen in Table 2. A possible explanation for this apparent discrepancy is that ADL-dependent or mobility-impaired males do not live as long as dependent or impaired females. Using the Cox proportional hazards method and controlling for age, we found that males who were ADL dependent or mobility impaired at baseline had 1.82 times the mortality risk of females who were similarly dependent or impaired (95 percent confidence interval = 1.04–3.18).

Table 4 further indicates that Blacks had higher incident ADL dependence and mobility impairment

than did non-Blacks. The difference in ADL-dependence was statistically significant ($\chi^2 = 5.1$, $p = .03$), but the difference in mobility impairment was not ($\chi^2 = 0.25$, $P = .62$). These higher incidence rates for Blacks appear to occur only for males, although the small numbers require that such generalizations should be made with caution.

Analysis of Black/Non-Black Differences Table 5 presents the multiple regression analyses exploring possible reasons for the poorer functioning and disability rates found for Blacks compared with non-Blacks both at baseline and follow-up. Coefficients in the first column represent the estimated mean difference between Blacks and non-Blacks on the 1984 function scale score, while the second column of coefficients represents the estimated mean difference between Blacks and non-Blacks for change (1990–1984) in the function scale score. Negative coefficients indicate lower baseline functioning or greater decline in functioning during follow-up for Blacks compared with non-Blacks. Five different models with successive controls are presented.

The demographic, SES, and behavioral/social adjustments produced little change in the relationship between ethnicity and baseline functioning. When the model was also adjusted for prevalent chronic conditions, the multiple regression coefficient for the 1984 function score dropped from −6.0 to −3.4. The effects of ethnicity were thus reduced but not eliminated. The difference in baseline score between Blacks and non-Blacks remained significant. For the analysis involving change in function during follow-up, the initial Black/non-Black difference of 2.1 points was not statistically significant. This difference changed little when the demographic, life-style, and prevalent chronic conditions variables were added in the second, fourth, and fifth models. The SES adjustment in the third model appeared to have the largest impact, but none of the relationships involving change in function was statistically significant.

Finally, we examined the differences between Blacks and non-Blacks on prevalence of the nine chronic conditions used in the fifth model to see where the differences between the two groups were. Blacks had a higher prevalence of diabetes, high blood pressure, stroke, and asthma. Furthermore, 64% of the Blacks reported having two or more of the nine chronic conditions compared with only 46% of the non-Blacks.

DISCUSSION

The sample in this study is very similar to the older population of the United States on all the characteristics summarized in Table 1 except education (49% high school graduate or more nationally vs 62% in our sample), marital status (55% married nationally vs 70%), and prevalence of arthritis (48% nationally vs 62%).[1,23–26]

The results from this representative sample of elderly persons show modestly increasing ADL dependence, mobility impairment, and reduced function between ages 65 and 80, with a sharp increase in dependence and impairment coupled with a sharp decrease in functioning for those 80 and older. Such a curvilinear relationship between age and functioning in old age can be seen in national data for ADL dependence[25] and most recently for both ADL dependence and mobility impairment in results reported from the four EPESE studies.[5,6] While it is possible that at some point in old age humans begin to lose their ability to maintain physiologic homeostasis, leading to more general system failure, there is much individual variability in the data reported here; even in the 80-and-over category, 10%–25% of the respondents improved in functioning over the 6-year follow-up period.

Higher ADL-dependence and mobility-impairment rates for older females as compared to older males of similar age have been reported elsewhere,[5,11,25] although not universally so.[27] Our data indicate that while mortality rates for males were higher than for females, more surviving females reported subsequent decline than males, and their average decline score was greater in two of the three age categories.

The finding of similar incidence rates for ADL dependence and mobility impairment for males and females was in contrast to the higher prevalence rates of

TABLE 5. RELATIONSHIPS BETWEEN ETHNICITY AND TWO FUNCTION MEASURES CONTROLLING FOR DEMOGRAPHICS, SES, BEHAVIORAL/SOCIAL, AND PREVALENT CHRONIC CONDITIONS

Multiple Regression Model	1984 Function Score ($n = 504$) Estimate*	P Value	Function Score Change 1984 to 1990 ($n = 354$) Estimate**	P Value
Black/Non-Black	−6.0	0.001	−2.1	0.30
Adjusted for demographic variables	−5.8	0.001	−2.4	0.23
Adjusted for demographic and SES variables	−5.1	0.003	−1.2	0.59
Adjusted for demographic, SES, and behavioral/social variables	−5.1	0.001	−1.3	0.58
Adjusted for demographic, SES, behavioral/social, and prevalent chronic conditions	−3.4	0.02	−2.0	0.40

* *Values represent the estimated mean difference between Blacks and Non-Blacks on the 1984 function scale score with and without various adjustments.*

** *Values represent the estimated mean difference between Blacks and Non-Blacks for change (1984–1990) in the function scale score with and without various adjustments.*

dependence and impairment for females at baseline in all age groups as well as the greater drop in functioning for surviving females as compared with surviving males. Similar findings for ADL dependence based upon a 2-year follow-up were reported by Manton.[4] Further analysis of our data indicated that the explanation for a higher prevalence of frailty in older females compared to older males may lie in a longer survival time for dependent and impaired females. Both groups appear to become dependent and impaired at the same rate, but frail females simply live longer than frail males.

The higher death rate for Blacks in this cohort compared with non-Blacks is consistent with national data, where Blacks have an 8% higher death rate than Whites in the 65 and older category.[2] Since 1900 there has been evidence of a mortality cross-over for Blacks around age 75 when Black rates fall below those of Whites.[28] Previous analysis in the Alameda County study, based upon 17 years of follow-up, also found evidence for such a cross-over.[29] Unfortunately, in this study the number of Blacks was too small to test for any possible cross-over.

Blacks not only reported higher rates of initial ADL dependence and mobility impairment than non-Blacks, but lower initial function scores as well. Blacks also declined more than non-Blacks during the 6-year follow-up even when gender and age were controlled, but the difference was not statistically significant and therefore could be due to chance. Black males had higher rates of incident ADL dependence and mobility impairment than did non-Black males. Our analysis of possible reasons for the Black/non-Black differences in disability suggested that prevalent chronic conditions were responsible for some but by no means all the observed differences at baseline. Blacks had higher prevalence of diabetes, high blood pressure, stroke, and asthma as well as higher rates of co-morbidity. Similar differences in prevalence of these four chronic conditions (except stroke in the North Carolina EPESE study) among older Blacks and Whites have been noted in other studies.[5, 6, 23, 30] However, the higher prevalence of these chronic conditions appeared to have no effect on differences between Black and non-Black survivors on change in functioning during the 6-year follow-up, whereas SES variables appeared to have a modest impact. Our findings are different from those obtained by Mutchler and Burr[31] where SES variables explained much of the difference between older Blacks and Whites on ADL limitations in a cross-sectional analysis. Additional studies are needed to sort out the relative effects of SES on functioning for older Blacks and Whites, to examine reasons for the higher prevalence of chronic conditions among older Blacks, and to explain the remaining differences in function between Blacks and Whites.

Given that those 85 and older represent the most rapidly growing segment of those 65 and older,[2] communities are going to be faced with an increasing need to provide services to assist those with ADL dependence, mobility impairment, and reduced function. At the same time our data show that there is much diversity in functional change among elderly persons. There were strong differences within three broad age categories, between males and females, and between Blacks and non-Blacks. In spite of overall declines for all groups there were also persons in every age category who increased in function during the 6-year follow-up. Perhaps the greatest mistake would be to view older persons as homogeneous. Clarifying the reasons for such heterogeneity remains an important and challenging area of research that will significantly affect primary and secondary prevention in the elderly.

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