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Prevalence, Attributes, and Outcomes of Fitness and Frailty in Community-Dwelling Older Adults: Report From the Canadian Study of Health and Aging

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Background. Frailty and fitness are important attributes of older persons, but population samples of their prevalence, attributes, and outcomes are limited.

Methods. The authors report data from the community-dwelling sample ($n = 9008$) of the Canadian Study of Health and Aging, a representative, 5-year prospective cohort study. Fitness and frailty were determined by self-reported exercise and function level and testing of cognition.

Results. Among the community-dwelling elderly population, 171 per 1000 were very fit and 12 per 1000 were very frail. Frailty increased with age, so that by age 85 years and older, 44 per 1000 were very frail. The risk for adverse health outcomes increased markedly with frailty: Compared with older adults who exercise, those who were moderately or severely frail had a relative risk for institutionalization of 8.6 (95% confidence interval, 4.9 to 15.2) and for death of 7.3 (95% confidence interval, 4.7 to 11.4). These risks persist after adjustments for age, sex, comorbid conditions, and poor self-rated health. At all ages, men reported higher levels of exercise and less frailty compared with women. Decreased fitness and increased frailty were also associated with poor self-ratings of health (42% in the most frail vs 7% in the most fit), more comorbid illnesses (6 vs 3), and more social isolation (34% vs 29%).

Conclusions. Fitness and frailty form a continuum and predict survival. Exercise influences survival, even in old age. Relative fitness and frailty can be determined quickly in a clinical setting, are potentially useful markers of the risk for adverse health outcomes, and add value to traditional medical assessments that focus on diagnoses.

THE health of the older population is a matter of great clinical, societal, and policy importance. Older adults have varying degrees of health, a heterogeneity that is often described as variable fitness and frailty. The concept of fitness encompasses beneficial health outcomes, including aerobic conditioning, muscle strength and feelings of vigor (1), and increased physiologic and cognitive functioning (2,3) that leads to a reduction in mortality rate (4) and fewer years of disability before death (5). Frailty is a more elusive and controversial concept, the various definitions of which often lack an empirical basis (6–10). Frailty is used to describe combinations of aging, disease, and factors such as nutritional status and functional ability that make some persons vulnerable to adverse health outcomes.

Comparatively few comprehensive assessments of older populations have employed readily usable definitions of fitness and frailty (11,12). Previously, we described a simple means for classifying frailty based on previously developed clinical assessments of cognition and function (7,12,13). The validity of this classification was tested by assessment of its content and by its ability to predict the risk for institutionalization and death (13). Now we extend this work to incorporate an assessment of levels of fitness (14) and to estimate the prevalence, attributes, and outcomes of fitness and frailty in elderly Canadians. Our aim is to describe fitness and frailty in terms that can be readily operationalized by clinicians.

Methods

The Canadian Study of Health and Aging (CSHA) is a national cohort study of the epidemiology of dementia and of the health status of older adults. It has been described in detail elsewhere (12,15,16). Briefly, in the community sample, recruited in the years 1991 and 1992, 9008 older adults were selected from comprehensive sampling frames. Participants were stratified by age (65 to 74 years, 75 to 84 years, and ≥85 years) with 2:1 and 2.5:1 oversampling of the two older cohorts, respectively. The sample was clustered by area at 36 urban sites and their surrounding rural communities. The response rate at baseline was 72%. Follow-up information on vital status and nursing home residence was obtained for 98% of the participants 5 years after the baseline assessment (17).

Participants were first screened for cognitive impairment using the 100-point Modified Mini-Mental State Examination (MMSE) (18). Those who screened positive (scoring <78 of 100 points on the Modified MMSE) and a sample who screened negative received a clinical examination. This assessment included a standard history and physical examination (19) and a neuropsychological test battery (20). In addition to rating the participants as having either dementia or no cognitive impairment, an intermediate category of "cognitive impairment, no dementia" (21,22) was devised to describe those who, although cognitively impaired, did not meet formal dementia criteria (23).

As described elsewhere (13), the operational definition of frailty was based on the Geriatric Status Scale (24). This scale, also used in clinical studies (24,25), combines aspects of cognitive and functional performance to describe various degrees of frailty. Thus, frailty can be mild (mild cognitive impairment only, or self-reported impairment in at least one instrumental activity of daily living with normal cognitive function, here a Modified MMSE score >77), moderate [mild dementia, as diagnosed above, or self-reported impairment of intermediate activities of daily living (26) with normal cognitive function], or severe (moderate or worse dementia or self-reported impairment of personal activities of daily living, regardless of level of cognitive impairment). In an earlier analysis (13), we separated those with isolated urinary incontinence as falling between no and mild frailty, and we combined moderate and severe frailty.

In earlier frailty studies, we did not grade fitness, so that here those who were previously described as "0" on the scale (these being older adults who were well and capable) are now further classified based on their levels of self-reported exercise. Using exercise as a surrogate for frailty, we stratified four groups: a high level of exercise (more vigorous than walking, at least three times per week), moderate exercise (walking three times per week), a low level of exercise (either walking, or exercise more vigorous than walking fewer than three times per week, or exercise less vigorous than walking at any frequency), and a no-exercise group. This approach has been shown to be reliable (test–retest reliability of 0.80 for frequency and 0.75 for intensity) and to have good predictive validity (14). The combined exercise variables have also been found to increase the risk for dementia (27).

The exercise and function questions were not mutually exclusive, so that 271 respondents reported both regular exercise and functional dependence (save incontinence). So that estimates of the risk for frailty would be conservative, we assigned such persons to the highest exercise category that they reported. Self-rated health was assessed by asking "How is your health these days?" (very good, pretty good, not too good, and poor or very poor). Comorbidity was assessed by a simple count of self-reported conditions from questionnaire prompts.

We report prevalence estimates, relative risks, and 95% confidence intervals (CIs). Kaplan-Meier curves for survival are presented. We performed a multivariable analysis using logistic regression with time-dependent covariates as appropriate, from which odds ratios and 95% CIs are presented.

Results

Figure 1 shows the prevalence of fitness and frailty by age and sex for older adults who live in the community. With increasing age, the prevalence of frailty increased from 70 per 1000 (95% CI, 63–78 per 1000) in those aged 65 to 74 years, to 175 per 1000 (95% CI, 158–193) in those aged 75 to 84 years, and 366 per 1000 (95% CI, 306–425) of those aged 85 years and older. The proportion of persons who exercise decreased, so that although 195 per 1000 (95% CI, 184–207) persons aged 65 to 74 years reported high exercise levels, this decreased to 128 per 1000 (95% CI, 113–144) of those aged 75 to 84 years, and to 62 per 1000 (95% CI, 33–92) in the oldest group surveyed. The prevalence of isolated urinary incontinence also increased with age. In general, more women were frail.

Table 1 presents selected demographic and health characteristics of older adults who exhibit various degrees of frailty. As the level of frailty increased, so did the mean level of comorbid illness, the tendency to rate their health poorly, and the proportion of persons who were unmarried. Most participants reported having a regular family physician.

Figure 2 shows Kaplan-Meier survival curves for each level of exercise and frailty. A dose-response effect in relation to death was evident, and those with moderate to severe frailty were at highest risk. Figure 3 illustrates the impact of various levels of exercise and frailty on institutionalization, with Kaplan-Meier survival curves indicating institution-free survival, again showing a dose response with the greatest likelihood of institutional admission occurring among the most frail. Decreasing fitness and increasing frailty were associated with an increased 5-year risk for death in both the adjusted and unadjusted models (Table 2). In the adjusted multivariable model, the level of fitness and frailty and age were the most important predictors of death or institutionalization.

Discussion

We investigated characteristics of persons with various levels of fitness and frailty in the Canadian Study of Health and Aging. Frailty increased with age, was more common in women, and was associated with adverse outcomes.

Our data must be interpreted with caution. The prevalence estimates relate only to community-dwelling older adults and thus are conservative estimates of the true population prevalence. Inclusion of those who are institutionalized would have had the greatest impact on the population prevalence for the very elderly, among whom the prevalence of institutionalization is very high and most of those institutionalized are frail (28). Including those in institutions, using a comparable definition of frailty, increases the prevalence to 626 per 1000 men and 654 per 1000 women in the oldest groups, and the overall frailty prevalence to 299 per 1000 and 333 per 1000 for men and women, respectively (12). In addition, even though our sample size is large ($n = 9008$), the refusal rate was 27.9%. Because CSHA nonrespondents

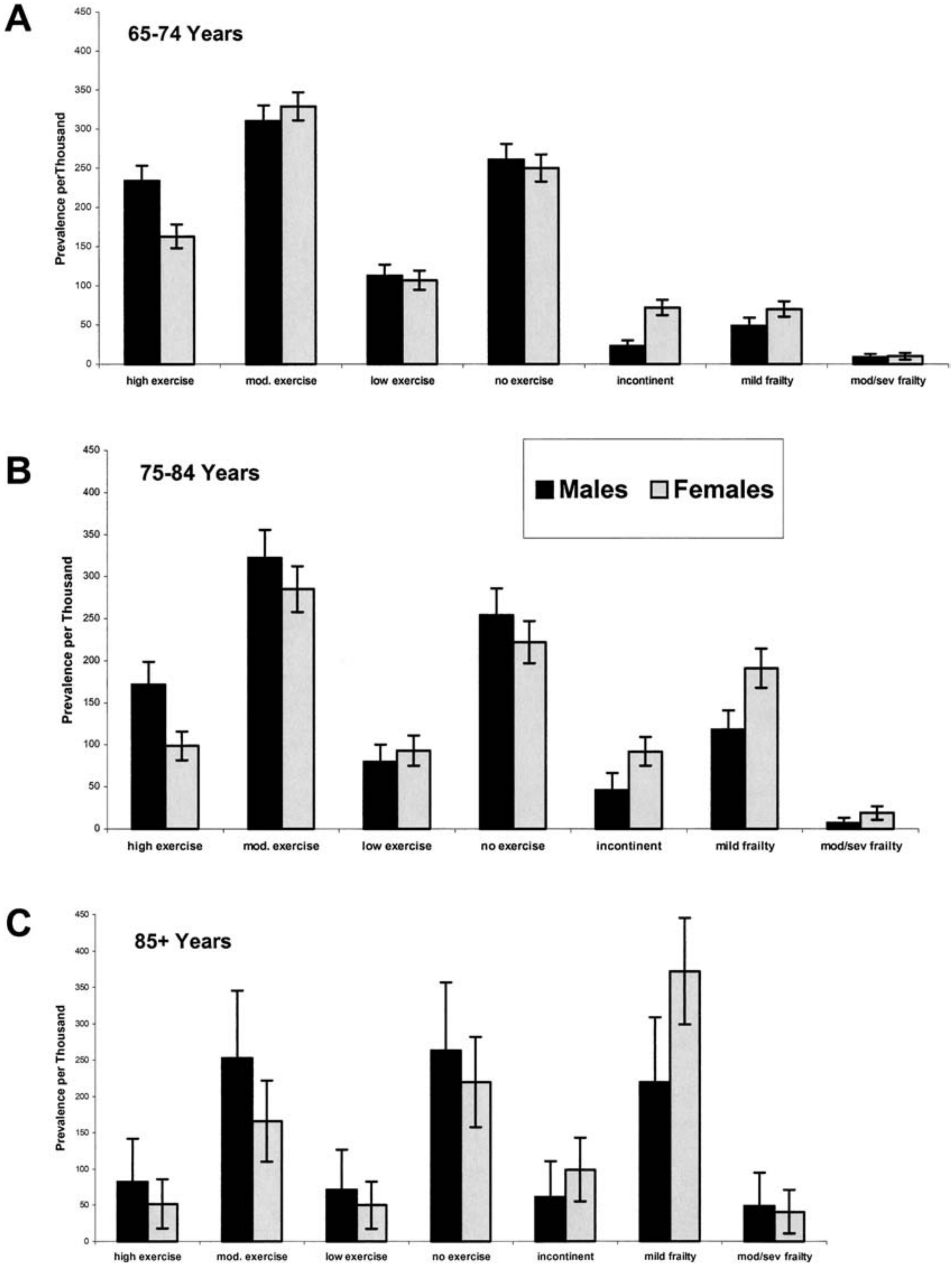

Figure 1. Prevalence of fitness and frailty per 1000 people, by age group and sex. **A:** Ages 65–74 years; **B:** ages 75–84 years; **C:** ages 85+ years.

tended to be older, the effect is again to make the estimates of prevalence conservative (29).

Perhaps the chief difficulty in determining the prevalence of fitness and frailty lies in agreeing on exactly how to define frailty (7,10,12,30,31). Here we have defined fitness and frailty in terms that are readily identifiable clinically, without special instrumentation. Although this lacks the precision of related constructs such as allostatic load (32), we have shown that this brief clinical assessment of frailty shows good predictive validity (13).

Compared with our earlier investigation (13), here we also classified fitness based on self-reported exercise levels. One consequence evident from the survival curves is that the formerly clear separation of outcomes between persons with

Table 1. Selected Demographic and Health Characteristics of Community-Dwelling Older People Exhibiting Varying Degrees of Fitness and Frailty

	High Exercise	Moderate Exercise	Low Exercise	No Exercise	Isolated Incontinence	Mild Frailty	Moderate/Severe Frailty
Age (y)*							
Mean (*SD*)	72.6 (5.6)	73.8 (6.2)	73.4 (6.1)	74.2 (6.4)	76.2 (6.6)	78.9 (7.1)	78.5 (7.8)
Education (y)*							
Mean (*SD*)	11.6 (3.8)	11.1 (3.7)	10.9 (3.7)	10.0 (3.7)	10.2 (3.9)	10.5 (3.6)	9.9 (4.0)
3 MS Score*							
Mean (*SD*)	91.3 (6.0)	90.6 (5.9)	90.3 (6.3)	88.9 (6.2)	89.8 (5.4)	87.5 (6.9)	85.0 (9.3)
Comorbid Illnesses*							
Mean (*SD*)	3.0 (2.1)	3.3 (2.1)	3.3 (2.2)	3.6 (2.3)	5.0 (2.6)	5.7 (2.6)	6.0 (3.3)
Unmarried*							
N (%)	347 (35.6)	832 (43.3)	245 (42.9)	606 (41.9)	201 (51.7)	502 (63.1)	62 (60.2)
Live alone*							
N (%)	287 (29.4)	682 (35.5)	186 (32.6)	435 (30.1)	153 (39.3)	385 (48.4)	35 (34.0)
Poor health*							
N (%)	65 (6.7)	179 (9.3)	58 (10.2)	240 (16.6)	92 (23.6)	289 (35.4)	43 (42.2)
Someone to help							
N (%)	948 (97.2)	1981 (97.9)	560 (98.2)	1401 (96.8)	379 (97.4)	771 (97.0)	98 (95.2)
Regular doctor**							
N (%)	945 (96.9)	1873 (97.5)	539 (94.6)	1395 (96.5)	381 (97.9)	779 (98.2)	100 (98.0)

Notes: $*p < .0001$; $**p < .003$.
SD = standard deviation.

isolated urinary incontinence and those defined as ''not frail'' no longer holds when degrees of fitness are considered. Consequently, the value of this category as a classifier of relevant and nonarbitrary outcomes is suspect. Necessarily, in subclassifying those who were not ''not frail'' by grades of fitness, we had to consider how to classify persons who both reported regular exercise and were clinically assessed as having attributes of frailty. As noted, we assigned such cases to their highest self-reported level of exercise. Again, the effect is to make conservative our estimates of the adverse outcomes associated with frailty. In this context, we considered the possibility that fitness and frailty were part of a continuum, or whether they were distinct concepts. Both the data on characteristics of

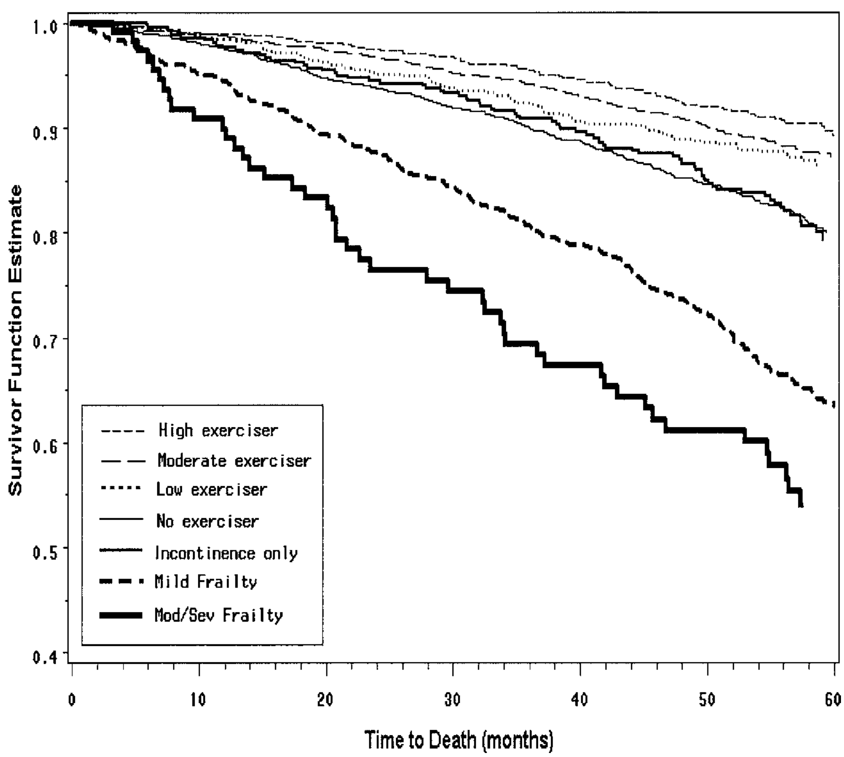

Figure 2. Kaplan-Meier survival curves, by level of fitness and frailty.

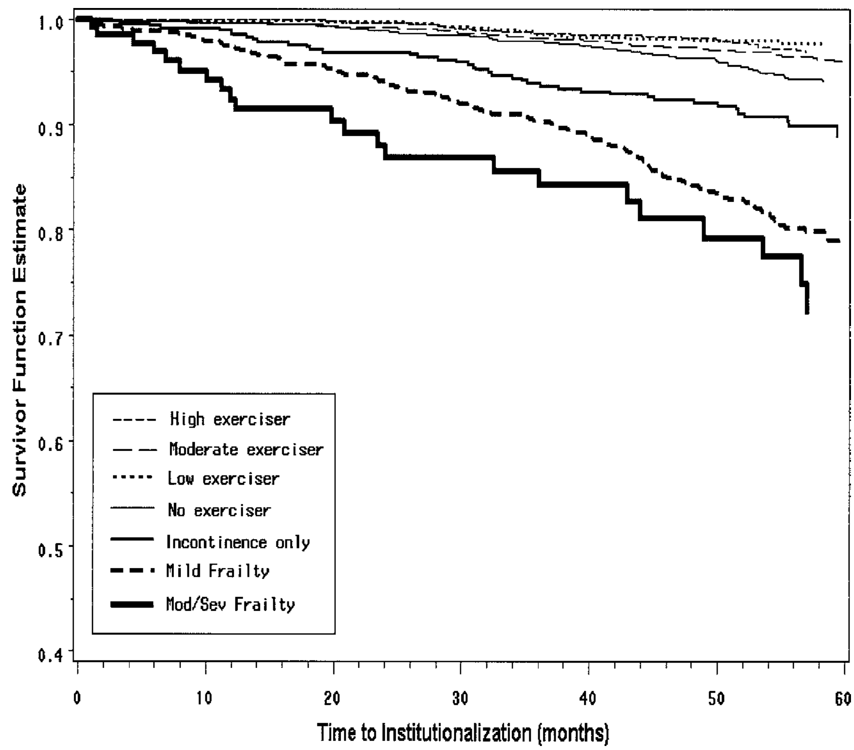

Figure 3. Kaplan-Meier survival curves for time to institutionalization, by level of fitness and frailty.

the population (Table 1) and their outcomes (Table 2) suggest that they do form a continuum. This interpretation also fits with another recent estimate for classifying fitness and frailty, based on self-reported data from the CSHA (33). In that approach, frailty was derived from an impairment index that showed a high correlation ($r = 0.99$) with chronologic age, suggesting that a continuum is likely.

Our use of self-reported exercise data might also be questioned on the grounds of social acceptability bias (i.e., that some persons will be inclined to report higher levels of exercise than they actually perform). However, the prevalence of exercise has been estimated in the Canada Heart Health Survey (34) as 57% of Canadians aged 65 to 74 years. From this we can conclude that ours remains a conservative estimate.

In this study, in the absence of more physiologic measures, we have equated self-reported physical activity patterns with fitness. The relationship between self-reported measures of physical activity in samples that include an important proportion of older adults and physiologic measures, however, varies (35–37). Conversely, in demonstrating a link between self-reported fitness and death, and self-reported fitness and other measures of well-being (such as self-reported health), we have provided both criterion and construct validation that self-reported physical activity is more than a measure of exercise. It would seem to extend to health status, and thus fitness seems reasonable in this context and as a means to extend this work to other population studies.

In addition, our study's definition of frailty was cross-sectional from the baseline and did not include dynamic components or items such as social support (beyond living arrangements) that occur outside the individual but that nevertheless also affect health (6). Our measure did not

Table 2. Adjusted and Unadjusted Risks for Death and Institutionalization for Levels of Fitness and Frailty

	Risk for Death		Risk for Institutionalization	
	Unadjusted (95% CI)	Adjusted* (95% CI)	Unadjusted (95% CI)	Adjusted* (95% CI)
High exercise	1.00	1.00	1.00	1.00
Moderate exercise	1.24 (0.97, 1.59)	1.16 (0.90, 1.50)	1.30 (0.88, 1.92)	1.07 (0.71, 1.62)
Low exercise	1.50 (1.10, 2.04)	1.51 (1.09, 2.08)	0.94 (0.54, 1.65)	0.82 (0.46, 1.45)
No exercise	2.16 (1.69, 2.76)	1.81 (1.40, 2.33)	1.95 (1.32, 2.88)	1.38 (0.91, 2.09)
Isolated incontinence	2.19 (1.59, 302)	1.60 (1.13, 2.26)	3.20 (2.01, 5.08)	1.69 (1.03, 2.79)
Mild frailty	4.82 (3.74, 6.21)	2.54 (1.92, 3.37)	7.28 (5.01, 10.58)	2.54 (1.67, 3.86)
Moderate/severe frailty	7.34 (4.73, 11.38)	3.69 (2.26, 6.02)	8.64 (4.92, 15.17)	2.60 (1.36, 4.96)

Notes: *Models were adjusted for age, sex, years of education, comorbid illnesses, being unmarried, living alone, poor self-reported health, and having a regular doctor.

CI = confidence interval.

include change scores, which, given the dynamic nature of the interaction between factors (6,9,38–40), would have been preferable. Conversely, in contrast to emergent definitions of frailty, this definition is readily operationalized.

In this study, we recognized that frailty can have physical and cognitive components. The relative contributions of cognitive and functional impairment to the estimates of frailty are of interest. Among those participants described as mildly frail, 71.3% had functional impairment alone, 14.4% had cognitive impairment alone, and 14.3% had both. For those who were moderately or severely frail, coincident functional and cognitive impairments were more common, occurring in 28.1%. Given the goals of the CSHA, we had access to its formal diagnostic process (15–23). A procedure based on self-reported functional impairment and definition of cognitive impairment by using Modified MMSE (18) cutpoints works about as well, but in such cases the ''cognitive impairment, no dementia'' criterion for mild frailty must be omitted, because there is no simple way to distinguish between mild functional impairment that is caused by cognitive impairment (in other words, mild dementia) and functional impairment seen with mild cognitive impairment that is not caused by it, as is commonly seen in ''cognitive impairment, no dementia'' (21,22).

In an Italian study of physical disability in relation to cognitive impairment and comorbid illness (41), these items were assessed separately. Although physical disability was commonly seen in relation to cognitive impairment, there were more comorbid illnesses among those without cognitive impairment than in those with dementia (41). Similarly, Binder and colleagues (42) found that processing speed on psychometric tests was an important correlate of physical frailty, and Van Schoor and colleagues (43) showed that persons with immediate memory impairment are at greater risk for falling. Perhaps the most important general observation is therefore the inter-relatedness of high-order processes (8,9,44), such that impairment in compromised persons can result in failure of high-order functions (such as staying upright or maintaining attention). Similar considerations likely underlie observations that ''dual tasking'' can be particularly challenging among the frail (45,46) and even that walking speed is a predictor of self-rated health (47).

Fried and colleagues (11) have also defined frailty in terms that lend themselves to ready operationalization, by including such variables as unintentional weight loss (10 lbs in the past year), self-reported exhaustion, weakness (grip strength), slow walking speed, and low physical activity. In doing so, they have usefully unlinked frailty from both disability and comorbid illness. In this study, we included disability information in the definition but were able to assess frailty in relation to disability. The rates of frailty that we found were slightly higher than those in their report, from the Cardiovascular Health Study, in which the estimated rates of frailty are 39 in 1000 of those aged 65 to 74 years and 250 in 1000 of those older than 85 years (11). They also reported comparable risks for frailty in relation to adverse health outcomes, including death (unadjusted 7-year risk, 4.46; 95% CI, 3.61–5.51).

An alternative to a rules-based frailty definition is an empirical estimate, based on the accumulation of deficits with age. This strategy, comparable to the concept of allostatic load (32), has been pursued elsewhere using Canadian population estimates (48,49), including the CSHA (33,50,51). Although the approach shows considerable promise, its translation into operational, clinical terms remains speculative (44).

We equated self-reported exercise with fitness, which obviously has limitations as a true estimate. Fitness, too, has many dimensions but is linked both to exercise and to several positive health outcomes (52,53), including the prevention of frailty (54). Furthermore, evidence exists that a person's self-perceived degree of fitness, and not just measured physical activity energy expenditure, is an important mediating variable in relation to disease risk (55). We found that even self-reported exercise level helped stratify groups of persons with respect to death and residence in nursing homes, which are particularly relevant and nonarbitrary outcomes for older adults. Furthermore, like the frailty assessment, it has the merit of being readily measurable by clinicians.

If we accept that the present approach has value, the data yield several potentially useful insights. For example, the proportion of persons who lived alone also increased in the mildly frail group, but it decreased in the group with moderate to severe frailty. This likely reflects the relatively greater difficulty of living alone with moderate to severe frailty and is consistent with its greatly increased risk for institutionalization.

Our data indicate that exercise is associated with positive health outcomes and thus join clinical and mechanistic studies that have reported beneficial effects (4,54,56). Considering that frailty is multifaceted and multifactorially determined, the manner by which exercise, a necessarily multifactorial intervention, confers these benefits remains undefined. For example, it has been shown that resistance exercise decreases tumor necrosis factor-α, itself associated with skeletal muscle wasting (57). Consequently, the benefits of exercise may extend beyond simple aerobic conditioning. Future studies relating exercise and frailty could fruitfully evaluate the nature of the beneficial effect of exercise. Such studies are warranted, given the likely biological, clinical, and public health implications of exercise and frailty.

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