present dabigatran may be suitable for patients with high stroke and bleeding risks such as frail older people with multiple comorbidities and polypharmacy in whom anticoagulation control is erratic or monitoring is not feasible. Until the price of dabigatran is reviewed, warfarin remains suitable for the majority of patients with NVAF.

Key points

- Cost of anticoagulation is largely driven by drug price for dabigatran and quality of INR control for warfarin.
- Cost of dabigatran to prevent one stroke per year is about four to five times that of warfarin.
- Majority of patients on warfarin therapy are not troubled by frequent blood testing.

References

1. Singer DE, Albers GW, Dalen JE *et al.*. Antithrombotic therapy in atrial fibrillation: the seventh ACCP Conference on antithrombotic and thrombolytic therapy. Chest 2004; 126 (Suppl): 429s–56s.
2. Wang TJ, Massaro JM, Levy D *et al.*. A risk score for predicting stroke or death in individuals with new onset atrial fibrillation in the community: the Framingham Heart Study. JAMA 2003; 290: 1049–56.
3. Hart RG, Pearce LA, Aguilar MI. Meta-analysis: antithrombotic therapy to prevent stroke in patients who have nonvalvular atrial fibrillation. Ann Intern Med 2007; 146: 857–67.
4. Boulanger L, Kim J. Patterns of use of antithrombotic therapy and quality of anticoagulation among patients with nonvalvular atrial fibrillation in clinical practice. Int J Clin Pract 2006; 60: 258–64.
5. Connnolly SJ, Ezekowitz MD, Yusuf S *et al.*. The RE-LY Steering Committee and Investigators: dabigatran versus warfarin in patients with atrial fibrillation. N Engl J Med 2009; 361: 1139–51.
6. Shah SV, Gage BF. Cost effectiveness of dabigatran for stroke prophylaxis in atrial fibrillation. Circulation 2011; 123: 2562–70.
7. Abdelhafiz AH, Wheeldon NM. Use of resources and cost implications of stroke prophylaxis with warfarin for patients with nonvalvular atrial fibrillation. Am J Geriatr Pharmacother 2003; l: 53–60.
8. O'Donoghue J, Goulding L, Allen G. Consumer price inflation since 1750. Eco Tren 2004; 604: 38–46.
9. National Institute for Health and Clinical Excellence. Final appraisal determination-dabigatran etexilate for the prevention of stroke and systemic embolism in atrial fibrillation. Issue date: October 2011.
10. Freeman JV, Zhu RP, Owens DK *et al.*. Cost-effectiveness of dabigatran compared with warfarin for stroke prevention in atrial fibrillation. Ann Intern Med 2011; 154: 1–11.
11. Wallentin L, Yusuf S, Ezekowitz MD *et al.*. RE-LY investigators. Efficacy and safety of dabigatran compared with warfarin at different levels of international normalized ratio control for stroke prevention in atrial fibrillation: an analysis of the RE-LY trial. Lancet 2010; 376: 975–83.
12. Gage BF, Waterman AD, Shannon W *et al.*. Validation of clinical classification schemes for predicting stroke: results from the National Registry of Atrial Fibrillation. JAMA 2001; 285: 2864–70.

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The frailty index in Europeans: association with age and mortality

Roman Romero-Ortuno, Rose Anne Kenny

Department of Medical Gerontology, Trinity College Dublin, Dublin, Ireland

Address correspondence to: R. Romero-Ortuno. Tel: (+353) 1 428 4527; Fax: (+353) 1 410 3454. E-mail: romeror@tcd.ie

Abstract

Background: the frailty index (FI) is an approach to the operationalisation of frailty based on accumulation of deficits. It has been less studied in Europeans.
Objective: to construct sex-specific FIs from a large sample of Europeans and study their associations with age and mortality.

Design: longitudinal population-based survey.
Setting: the Survey of Health, Ageing and Retirement in Europe (SHARE, http://share-dev.mpisoc.mpg.de/).
Subjects: a total of 16,217 females and 13,688 males aged ≥50 from wave 1 (2004–05). Mortality data were collected between 2005 and 2006 (mean follow-up: 2.4 years).
Methods: regression curve estimations between age and an FI constructed as per the standard procedure. Logistic regressions were used to assess the relative effects of age and the FI towards mortality.
Results: in both sexes, there was a significant non-linear association between age and the FI (females: quadratic $R^2 = 0.20$, $P < 0.001$; males: quadratic $R^2 = 0.14$, $P < 0.001$). Overall, the FI was a much stronger predictor of mortality than age, even after adjusting for the latter (females: age-adjusted OR 100.5, 95% confidence interval (CI): 46.3–218.2, $P < 0.001$; males: age-adjusted OR 221.1, 95% CI: 106.7–458.4, $P < 0.001$).
Conclusion: the FI had the expected properties in this large sample of Europeans.

: *frail elderly, health status index, mortality, frailty index, sex differences, elderly*

Introduction

Frailty is a non-specific state of dysregulation in multiple physiological systems, vulnerability to stressors and increased risk of adverse outcomes [1, 2]. Although frailty increases with age, it is more related to the biological than the chronological age of individuals [3]. In general, frailty is superior to age in identifying at-risk older people [4].

The frailty index (FI) has been proposed as an index of deficits (i.e. symptoms, signs, diseases and disabilities) that accumulate with age [5, 6]. An individual's FI score reflects the proportion of potential deficits present in that person, and indicates the likelihood that frailty is present. The FI is a continuous variable and primarily does not classify people as frail or non-frail but rather assigns a score based on health status.

The FI has been regarded as an adequate indicator of the ageing-associated processes because it characterises these processes independently of, and more efficiently than, chronological age [7]. The construct validity of the FI is examined through its relationship to chronological age, and its criterion validity is examined in its ability to predict mortality, and in relation to other predictions including disability and use of healthcare resources [8].

The rate of deficit accumulation is sex sensitive [9] and the FI appears to be a sensitive age-independent indicator of sex-specific physiological decline and a sex-specific discriminator of survival chances [10]. On average, women accumulate more deficits than men of the same age, but their risk of mortality is lower [11].

The majority of studies on FI have been conducted outside Europe and there was a relative paucity of studies in the European context. The Survey of Health, Ageing and Retirement in Europe (SHARE, http://share-dev.mpisoc.mpg.de/) represented a unique opportunity to create a standard FI in Europeans and examine its properties *vis-à-vis* previous FI studies in non-European populations.

Methods

Setting

The study is based on the Survey of Health, Ageing and Retirement in Europe (SHARE, http://share-dev.mpisoc.mpg.de/). Based on probability samples in all participating countries, SHARE represents the non-institutionalised population aged 50 and older. Spouses were also interviewed if they were younger than 50 but we excluded them from our analyses. The first wave was collected between 2004 and 2005.

FI construction

Based on the first wave of SHARE, a 40-item FI was created as per the standard procedure [12]. Each of the 40 deficit variables was scored such that 0 = deficit absent and 1 = deficit present. The scores were added and divided by the total number of deficits evaluated (i.e. 40), to produce an FI between 0.0 (no deficits present) and 1.0 (all deficits present). For full information on the FI deficit variables and cut-off points, see the Supplementary data available in *Age and Ageing* online, Appendix 1.

Mortality data

Mortality data (i.e. dead, alive or missing) were collected during the second wave of the study (2005–06). The mean follow-up period between wave 1 and wave 2 was 2.4 years.

Statistical analyses

Statistical analyses were conducted with SPSS 16.0, separately for each sex. A histogram of the FI was produced to assess its distribution. The FI (*Y*-axis) was plotted against age (*X*-axis) and the curve estimation procedure was used to assess the relative fit of linear and non-linear (i.e. quadratic, cubic, exponential) regression models. The sample was divided into age categories (i.e. 50s, 60s, 70s, 80s and ≥90) and their mean FIs with 95% confidence intervals

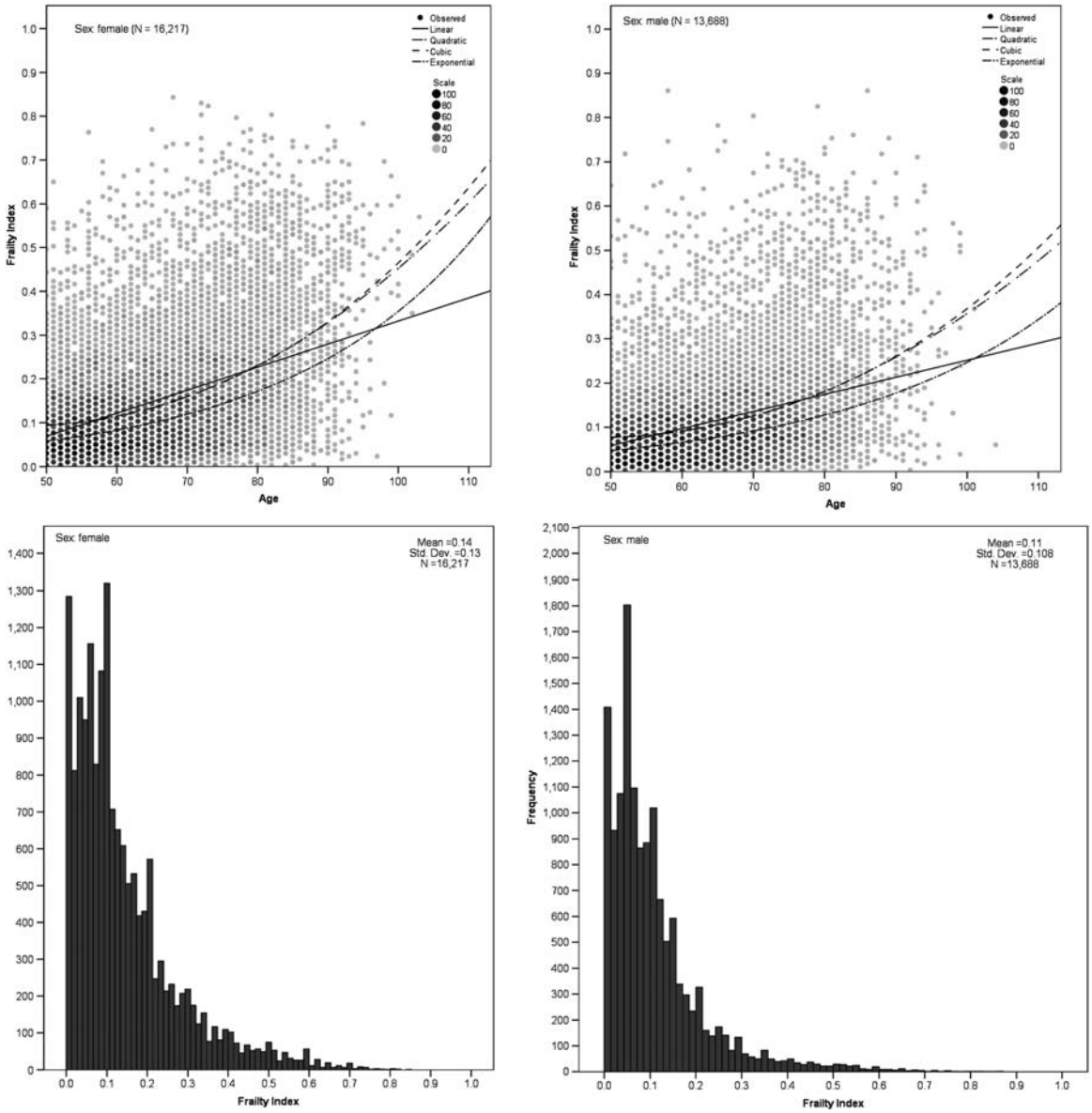

Figure 1. Distribution of the FI and correlation with age (by sex). Females: *linear* $R^2 = 0.187$, $P < 0.001$; *exponential* $R^2 = 0.150$, $P < 0.001$; *quadratic* $R^2 = 0.200$, $P < 0.001$; *cubic* $R^2 = 0.200$, $P < 0.001$. Males: *linear* $R^2 = 0.125$, $P < 0.001$; *exponential* $R^2 = 0.113$, $P < 0.001$; *quadratic* $R^2 = 0.136$, $P < 0.001$; *cubic* $R^2 = 0.136$, $P < 0.001$.

(CIs) were calculated, as well as their mortality rates. We also calculated the FI quartiles within age categories and their associated mortality rates. To assess the relative contributions of age and the FI towards mortality (in the total sample and within age subgroups), we used binary logistic regressions, unadjusted, and adjusted for age or FI as appropriate.

Results

The first wave of SHARE included 29,905 participants aged ≥50 years from 12 countries (Austria, Germany, Sweden, Netherlands, Spain, Italy, France, Denmark, Greece, Switzerland, Belgium, and Israel). There were 16,217 females (54.2%) with a mean (SD) age of 64.8 (10.4) years, and 13,688 males (45.8%) with a mean (SD) age of 64.3 (9.8) years.

The FI was obtained for every participant, but none had values for all 40 variables included in the FI. Thirty-nine variables had the recommended <5% of missing data [13]. Grip strength had 10.1% of missing data, but it was retained as it is known to be an important objective marker of frailty [14, 15]. As done by others [13], missing values for each variable were imputed using the non-missing mean of the variable. The correlation between the original FI and the imputed FI was extremely high (adjusted linear $R^2 = 0.99$, $P < 0.001$), so the original one was used. For full

Table 1. FI-associated mortality and relative contribution of chronological age (by sex)

Age	Mean FI (95% CI)	*n*	Mortality rate (%)	FI quartiles (within age group)	*n* (quartiles)	Mortality rate (%)	FI: unadjusted OR for mortality (95% CI, *P*)	FI: age-adjusted OR for mortality (95% CI, *P*)	Age: unadjusted OR for mortality (95% CI, *P*)	Age: FI-adjusted OR for mortality (95% CI, *P*)
Females	0.14 (SD 0.13)	16217	1.6				1260.8 (654.6–2428.6) $P < 0.001$	100.5 (46.3–218.2) $P < 0.001$	1.1 (1.1–1.2) $P < 0.001$	1.1 (1.1–1.1) $P < 0.001$
50s	0.10 (0.09–0.10)	6083	0.3	0.03 > FI	1224	0.0	382.5 (18.7–7833.0) $P < 0.001$	302.6 (14.2–6446.7) $P < 0.001$	1.1 (1.0–1.4) $P = 0.131$	1.1 (0.9–1.3) $P = 0.226$
				0.03 ≤ FI < 0.08	1774	0.2				
				0.08 ≤ FI < 0.13	1531	0.1				
				0.13 ≤ FI	1554	0.8				
60s	0.13 (0.12–0.13)	4970	0.8	0.05 > FI	1111	0.4	164.8 (23.1–1177.2) $P < 0.001$	140.9 (19.1–1038.6) $P < 0.001$	1.2 (1.0–1.3) $P = 0.011$	1.1 (1.0–1.3) $P = 0.027$
				0.05 ≤ FI < 0.10	1322	0.8				
				0.10 ≤ FI < 0.17	1249	0.6				
				0.17 ≤ FI	1288	1.3				
70s	0.18 (0.18–0.19)	3461	2.1	0.08 > FI	778	0.5	85.6 (23.3–315.0) $P < 0.001$	55.5 (14.6–210.9) $P < 0.001$	1.2 (1.1–1.3) $P < 0.001$	1.2 (1.1–1.3) $P < 0.001$
				0.08 ≤ FI < 0.15	898	1.9				
				0.15 ≤ FI < 0.25	890	2.0				
				0.25 ≤ FI	895	3.9				
80s	0.26 (0.25–0.27)	1460	5.8	0.13 > FI	351	0.6	154.1 (39.0–608.7) $P < 0.001$	137.0 (34.2–548.3) $P < 0.001$	1.1 (1.0–1.2) $P = 0.005$	1.1 (1.0–1.2) $P = 0.046$
				0.13 ≤ FI < 0.22	370	3.5				
				0.22 ≤ FI < 0.36	363	6.9				
				0.36 ≤ FI	376	12.0				
90+	0.36 (0.34–0.39)	243	20.6	0.19 > FI	52	3.8	95.1 (10.4–867.7) $P < 0.001$	71.0 (7.7–650.5) $P < 0.001$	1.2 (1.1–1.4) $P = 0.006$	1.2 (1.0–1.3) $P = 0.027$
				0.19 ≤ FI < 0.38	69	13.0				
				0.38 ≤ FI < 0.51	55	29.1				
				0.51 ≤ FI	67	34.3				
Males	0.11 (SD 0.11)	13688	2.6				1112.0 (570.5–2167.4) $P < 0.001$	221.1 (106.7–458.4) $P < 0.001$	1.1 (1.1–1.1) $P < 0.001$	1.1 (1.1–1.1) $P < 0.001$
50s	0.08 (0.08–0.08)	5153	0.8	0.02 > FI	1053	0.2	610.0 (81.9–4545.1) $P < 0.001$	565.6 (74.1–4315.2) $P < 0.001$	1.1 (1.0–1.2) $P = 0.131$	1.1 (1.0–1.2) $P = 0.247$
				0.02 ≤ FI < 0.06	1284	0.6				
				0.06 ≤ FI < 0.11	1480	0.4				
				0.11 ≤ FI	1336	1.8				
60s	0.10 (0.10–0.10)	4471	1.8	0.04 > FI	1086	0.6	543.5 (107.0–2761.4) $P < 0.001$	463.7 (89.7–2396.5) $P < 0.001$	1.1 (1.0–1.2) $P = 0.026$	1.1 (1.0–1.1) $P = 0.131$
				0.04 ≤ FI < 0.08	1132	1.1				
				0.08 ≤ FI < 0.13	1082	1.3				
				0.13 ≤ FI	1171	4.2				
70s	0.14 (0.14–0.15)	2996	4.2	0.06 > FI	745	1.6	356.7 (115.4–1101.9) $P < 0.001$	267.6 (85.1–841.5) $P < 0.001$	1.1 (1.1–1.2) $P < 0.001$	1.1 (1.0–1.2) $P = 0.019$
				0.06 ≤ FI < 0.11	691	1.3				
				0.11 ≤ FI < 0.19	811	4.7				
				0.19 ≤ FI	749	8.9				
80s	0.20 (0.19–0.21)	954	10.0	0.09 > FI	222	4.5	109.7 (26.6–451.7) $P < 0.001$	84.7 (20.1–357.1) $P < 0.001$	1.2 (1.1–1.3) $P < 0.001$	1.1 (1.0–1.2) $P = 0.003$
				0.09 ≤ FI < 0.16	242	7.9				
				0.16 ≤ FI < 0.27	243	10.7				
				0.27 ≤ FI	247	16.2				
90+	0.28 (0.24–0.31)	114	15.8	0.14 > FI	28	7.1	23.9 (0.8–677.8) $P = 0.063$	24.7 (0.8–733.0) $P = 0.064$	1.0 (0.8–1.2) $P = 0.928$	1.0 (0.8–1.2) $P = 0.903$
				0.14 ≤ FI < 0.25	28	21.4				
				0.25 ≤ FI < 0.41	28	17.9				
				0.41 ≤ FI	30	16.7				

information on missing data, see the Supplementary data available in *Age and Ageing* online, Appendix 2.

In females, the mean (SD) FI was 0.14 (0.13), and in males 0.11 (0.11). As Figure 1 shows, the distribution of the FI had the typical gamma distribution [12]. Figure 1 shows the results of the curve estimation procedures. In both sexes, the relationship between age and the FI was best described by a non-linear relationship (e.g. females: quadratic $R^2 = 0.20$, $P < 0.001$; males: quadratic $R^2 = 0.14$, $P < 0.001$). The mean FI values and values for comorbidity, disability and healthcare utilisation for each age group are plotted in the Supplementary data available in *Age and Ageing* online, Appendix 3.

Mortality data were available for 10,697 females and 9,092 males. Table 1 shows the overall and subgroup mortality rates, by sex. At all ages, and in both sexes, the FI was a much stronger predictor of mortality than chronological age. There were clinically significant differences in mortality between sexes, with males having greater mortality rates despite having lower mean FI values.

Discussion

We operationalised an FI in a large representative sample of community-dwelling Europeans. This adds to the existing literature because most studies on FI have been conducted outside Europe. Previous studies based on SHARE had used a definition based on frailty phenotype, and they also showed age-independent associations with their study outcomes [16, 17].

From a theoretical perspective, our scatter plots are consistent with the fact that, in humans, trajectories of health and functioning with age are extremely variable among individuals, owing to marked population heterogeneity [18]. It is known that the accumulation of deficits has both an age-independent (background) component and an age-dependent (exponential) component, akin to the well-known Gompertz-Makeham model for the risk of mortality [19], a generalised form of which is interpreted as a law of the dependency of mortality upon 'vitality' rather than on age [20].

The properties of the European FI are consistent with those of FIs operationalised elsewhere. In a representative, cross-sectional, Canadian survey Rockwood *et al.* showed that the FI was well fitted by a gamma distribution and increased exponentially with age [21]. Data from the National Long Term Care Survey in the USA showed that the FI exhibits accelerated increase with age until oldest ages, and longitudinal analysis confirmed the accelerated accumulation of deficits in ageing individuals [22]. The Health and Retirement Survey showed that the FI for cohorts born before 1942 exhibited quadratic increases with age and accelerated increases in the accumulation of health deficits [23]. Interestingly, the quadratic regression had better fit than the exponential regression in our population.

Regarding mortality, our results are consistent with previous studies showing that at all ages, a higher FI was associated with higher mortality [13, 24], and that the FI predicts death better than chronological age [22]. In the Chinese Longitudinal Healthy Longevity Survey, the FI was a robust predictor of mortality at advanced ages and the relationship between frailty and mortality was independent of age and other covariates [25].

The sex differences seen with our FI were also found elsewhere. In a Mexican population, women showed significantly higher mean FI values than men in the age groups younger than 80 years [26]. However, in a similar population, the association of the FI with mortality was found to be stronger among men [27]. In a Chinese population, the FI was higher in women than men for each age group, and women had an estimated 20% lesser chance of dying at a given time than did men of the same chronological age and degree of frailty [28]. Likewise, in the Beijing Longitudinal Study of Aging, deficits were more lethal in men than in women, although women had a higher mean level of frailty [29]. Various hypotheses try to explain these well-known sex differences in FI-associated mortality [30].

In conclusion, the properties of our FI were in keeping with those of FIs derived elsewhere. If the European FI is operationalised in practice, our findings may serve as a reference to help European practitioners identify at-risk patients who need priority access to resources.

Key points

- The FI has been less studied in Europeans.
- We constructed sex-specific FIs from a large sample of Europeans.
- We studied the FI associations with age and mortality.
- The FI had the expected properties.

Conflicts of interest

None declared.

Ethical approval

We undertook a secondary analysis of data obtained under the SHARE Data Access Rules (http://share-dev.mpisoc.mpg.de/data-access-documentation/research-data-center-data-access.html). Originally, SHARE received ethical approval by the University of Mannheim's Internal Review Board. All participants consented to the study.

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Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

References

1. Fedarko NS. The biology of aging and frailty. Clin Geriatr Med 2011; 27: 27–37.
2. Fulop T, Larbi A, Witkowski JM *et al*. Aging, frailty and age-related diseases. Biogerontology 2010; 11: 547–63.
3. Wick JY. Understanding frailty in the geriatric population. Consult Pharm 2011; 26: 634–45.
4. Schuurmans H, Steverink N, Lindenberg S, Frieswijk N, Slaets JP. Old or frail: what tells us more? J Gerontol A Biol Sci Med Sci 2004; 59: M962–5.
5. Rockwood K, Mitnitski A. Frailty defined by deficit accumulation and geriatric medicine defined by frailty. Clin Geriatr Med 2011; 27: 17–26.
6. Rockwood K, Mitnitski A. Frailty in relation to the accumulation of deficits. J Gerontol A Biol Sci Med Sci 2007; 62: 722–7.
7. Kulminski A, Yashin A, Arbeev K *et al*. Cumulative index of health disorders as an indicator of aging-associated processes in the elderly: results from analyses of the National Long Term Care Survey. Mech Ageing Dev 2007; 128: 250–8.
8. Mitnitski AB, Graham JE, Mogilner AJ, Rockwood K. Frailty, fitness and late-life mortality in relation to chronological and biological age. BMC Geriatr 2002; 2: 1.
9. Kulminski A, Yashin A, Ukraintseva S *et al*. Accumulation of health disorders as a systemic measure of aging: findings from the NLTCS data. Mech Ageing Dev 2006; 127: 840–8.
10. Kulminski AM, Ukraintseva SV, Akushevich IV, Arbeev KG, Yashin AI. Cumulative index of health deficiencies as a characteristic of long life. J Am Geriatr Soc 2007; 55: 935–40.
11. Mitnitski AB, Mogilner AJ, MacKnight C, Rockwood K. The mortality rate as a function of accumulated deficits in a frailty index. Mech Ageing Dev 2002; 123: 1457–60.
12. Searle SD, Mitnitski A, Gahbauer EA, Gill TM, Rockwood K. A standard procedure for creating a frailty index. BMC Geriatr 2008; 8: 24.
13. Song X, Mitnitski A, Rockwood K. Prevalence and 10-year outcomes of frailty in older adults in relation to deficit accumulation. J Am Geriatr Soc 2010; 58: 681–7.
14. Xue QL, Walston JD, Fried LP, Beamer BA. Prediction of risk of falling, physical disability, and frailty by rate of decline in grip strength: the women's health and aging study. Arch Intern Med 2011; 171: 1119–21.
15. Syddall H, Cooper C, Martin F, Briggs R, Aihie Sayer A. Is grip strength a useful single marker of frailty? Age Ageing 2003; 32: 650–6.
16. Romero-Ortuno R, O'Shea D, Kenny RA. The SHARE frailty instrument for primary care predicts incident disability in a European population-based sample. Qual Prim Care 2011; 19: 301–9.
17. Santos-Eggimann B, Cuenoud P, Spagnoli J, Junod J. Prevalence of frailty in middle-aged and older community-dwelling Europeans living in 10 countries. J Gerontol A Biol Sci Med Sci 2009; 64: 675–81.
18. Finkelstein M. On the 'rate of aging' in heterogeneous populations. Math Biosci 2011; 232: 20–3.
19. Mitnitski AB, Mogilner AJ, MacKnight C, Rockwood K. The accumulation of deficits with age and possible invariants of aging. ScientificWorldJournal 2002; 2: 1816–22.
20. Golubev AG. The issue of feasibility of a general theory of aging I. Generalized Gompertz-Makeham Law. Adv Gerontol 2009; 22: 60–73.
21. Rockwood K, Mogilner A, Mitnitski A. Changes with age in the distribution of a frailty index. Mech Ageing Dev 2004; 125: 517–9.
22. Kulminski A, Ukraintseva SV, Akushevich I, Arbeev KG, Land KYashin AI. Accelerated accumulation of health deficits as a characteristic of aging. Exp Gerontol 2007; 42: 963–70.
23. Yang Y, Lee LC. Dynamics and heterogeneity in the process of human frailty and aging: evidence from the U.S. older adult population. J Gerontol B Psychol Sci Soc Sci 2010; 65B: 246–55.
24. Rockwood K, Song X, Mitnitski A. Changes in relative fitness and frailty across the adult lifespan: evidence from the Canadian National Population Health Survey. CMAJ 2011; 183: E487–94.
25. Gu D, Dupre ME, Sautter J, Zhu H, Liu Y, Yi Z. Frailty and mortality among Chinese at advanced ages. J Gerontol B Psychol Sci Soc Sci 2009; 64: 279–89.
26. Garcia-Gonzalez JJ, Garcia-Pena C, Franco-Marina F, Gutierrez-Robledo LM. A frailty index to predict the mortality risk in a population of senior Mexican adults. BMC Geriatr 2009; 9: 47.
27. Berges IM, Graham JE, Ostir GV, Markides KS, Ottenbacher KJ. Sex differences in mortality among older frail Mexican Americans. J Womens Health (Larchmt) 2009; 18: 1647–51.
28. Goggins WB, Woo J, Sham A, Ho SC. Frailty index as a measure of biological age in a Chinese population. J Gerontol A Biol Sci Med Sci 2005; 60: 1046–51.
29. Shi J, Song X, Yu P *et al*. Analysis of frailty and survival from late middle age in the Beijing Longitudinal Study of Aging. BMC Geriatr 2011; 11: 17.
30. Hubbard RE, Rockwood K. Frailty in older women. Maturitas 2011; 69: 203–7.

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