Comparison of two frailty indexes in hip fractures

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Abstract
Aim: Modified-Krishnan’s frailty index (FI) is an FI calculation method developed by Krishnan et al. in 2014. This study aimed to compare the effectiveness and correlation of the FIs from Krishnan and the Canadian study of health and aging (CSHA) in predicting postoperative outcomes of elderly patients with hip fracture. Methods: Based on clinical follow-up and observation, we utilized these two instruments to predict 3-month mortality, hip function, and recovery of daily activities. The area under the curve (AUC) and the Pearson correlation coefficient were used to compare the two scales’ predictive validities for postoperative outcomes. Results: A total of 130 patients were included; 67% female and mean age 77.5 ± 8.5 years. The AUCs of modified-Krishnan’s FI (AUC = 0.856; 95% confidence interval (CI) = 0.767–0.945) and the CSHA-FI (AUC = 0.793; 95% CI = 0.652–0.934) were used to compare the effectiveness in predicting patient mortality. The optimal predictive scores were 0.335 and 0.28, respectively. The Pearson correlation analysis showed that the modified-Krishnan’s FI correlated with the Japanese Orthopaedic Association hip score (pain, activity, walking ability, and ability for daily living; R = −0.249, p = 0.005), while the CSHA-FI was not correlated (R = −0.125, p = 0.170). The modified-Krishnan’s FI (R = −0.415, p < 0.001) and the CSHA-FI (R = −0.332, p < 0.001) were both significantly correlated with the functional recovery scale score. Conclusions: The modified-Krishnan’s FI and the CSHA-FI were effective in the prediction of postoperative mortality. But the modified-Krishnan’s FI was more consistently associated with the recovery of hip function and daily activities at 3 months after the operation than that of the CSHA-FI. The modified-Krishnan’s FI was more suitable to utilize for risk stratification, identifying deficits, and predicting recovery capacity in hip fracture patients.

Keywords
aged, forecasting, frailty, hip fractures, prognosis

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Introduction
In an aging society, hip fracture is a major public health issue and results in poor outcomes such as disability and high mortality.¹,² Most current surgical risk measures for hip fracture are based on comorbidities or physical signs, excluding important factors such as energy, physical ability, and detailed cognition that the frailty index (FI) captures. Frailty is a state of vulnerability and characterized by the poor resolution of homeostasis after a stressor event, a consequence of a cumulative decline in many physiological systems during a lifetime.³ Studies have demonstrated that frailty helps predict hip fracture patients’ 30-day,¹ ¹-, and 2-year mortality rates⁴ and is associated with increased length of hospital stay (LOS)⁴,⁶ and postoperative complications.⁶ The modified-Krishnan’s FI defines the frailty of hip fracture patients on days 3–5 postoperatively and links frailty to outcomes. They found that this FI was...
significantly correlated with adverse outcomes, including 30-day mortality, LOS, and failure to return home. However, they did not explore the relationships between preoperative frailty and rehabilitation. Several studies have documented the FI preoperatively, not postoperatively. The appeal of measuring frailty preoperatively lies in its utility both as a tool for risk stratification and as a method for identifying potentially modifiable factors that can be optimized preoperatively. Although this FI uses weighted variables, the cut points of some deficits (e.g., proximal muscle strength, grip strength, and weight) are vague, and some abstract deficits (e.g., self-rated health and the ability to manage finances) are rated on perception.

The Canadian study of health and aging frailty index (CSHA-FI) is closely correlated with a more multidimensional concept of frailty. The modified FI (mFI) derived from the CSHA has been used in hip fracture and is associated with 1- and 2-year mortality rates after a femoral neck fracture. However, mFI mainly involves comorbidities and functional assessment and is too simple for comprehensive assessment. Although the FI was proven to have robust reproducibility, it used unweighted variables in which every deficit was equally important.

Despite the modified-Krishnan’s FI and the CSHA-FI measuring similar variables, it is no clear which is more effective in predicting the adverse outcomes. This prospective study aims to (i) explore the feasibility and validity of modified-Krishnan’s FI, (ii) compare the capacity of the two indexes to predict the mortality, (iii) correlate preoperative frailty and postoperative hip function or recovery, and (iv) identify which FI is most suitable for hip fracture patients.

Materials and methods

Study subjects

A total of 136 consecutive patients with hip fractures who were treated in the Department of Orthopaedics in the First Affiliated Hospital of Fujian Medical University between November 1, 2015, and October 31, 2016, were included in this longitudinal and observational study. Six patients were excluded due to refusal of surgical treatment (two patients) and loss to follow-up (four patients). Therefore, 130 patients who met the inclusion criteria were included in this study.

Inclusion criteria are

1. unilateral femoral neck fracture or intertrochanteric fracture as diagnosed by radiograph, computed tomography (CT), or magnetic resonance imaging (MRI);
2. age ≥ 60 years;
3. undergoing first-time hip fracture surgery in the ipsilateral hip or lower limb; and
4. informed consent form was obtained.

Exclusion criteria are

1. had additional fractures other than in the hip,
2. pathological fractures, and
3. a history of fractures in the ipsilateral hip or lower limb within the previous year.

Research tools

Modified-Krishnan’s FI. The modified-Krishnan’s FI was designed to assess the frailty in elderly patients with hip fractures, including six aspects, namely, physical health, mental health, cognitive function, self-care ability, life satisfaction, and social function. The FI was calculated as the sum of the scores of missing items/total score (55) × 100%. Because not all variables have been published or had self-evident cut points, we established the measuring criteria of the cut points based on behavior characteristics and references. Table 1 shows modified-Krishnan’s FI deficit variables and cutoff points.

CSHA-FI. The CSHA-FI was developed by Rockwood et al., specializing in the following aspects: cognition, existing diseases, self-care deficits, and abnormal physical signs, among others. The CSHA-FI was calculated as the number of deficits of the health items/the number of elderly health items. The value range was 0–1. All binary variables were recorded, scored for 0 = Deficit absent and 1 = Deficit present.

Outcomes. The main outcomes were the data related to death, the rate of readmission to the hospital, and fall within 3 months of the index surgery. Hip function and daily activities were measured at 3 months postoperation. Hip function was measured using the Japanese Orthopaedic Association (JOA) hip score. The recovery of daily activities was measured by the functional recovery scale (FRS) developed by Zuckerman et al. LOS and postoperative complications were collected. The complications included hypoproteinemia, anemia, electrolyte disturbance, pulmonary infection, urinary tract infection, vital organ failure (including heart failure, respiratory failure, hepatic failure, and kidney failure), delirium, pressure sores, lower limb venous thrombosis, incision infection, prosthesis-related complications, and stress ulcer were recorded.

Data collection methods

The study received ethical approval of the Medical Ethics Committee of the First Affiliated Hospital of Fujian Medical University (no. 2017-138). Patients were given informed consent unless they were cognitively impaired,
first, we remeasured the inter-rater reliability of the modified-Krishnan’s FI. Two different examiners blinded to each other administered the FI. The assessments were always administered 2 days apart before the operation. Then, the researcher completed the survey based on the baseline characteristics, the modified-Krishnan’s FI, and the CSHA-FI through patient encounters or patient medical records within 72 h after admission. Obtained baseline characteristics included the following: age, sex, activity of daily living (ADL), time of admission and operation, and fracture type. The JOA and FRS were measured by the

| Deficits counted | Points (max denominator 55) | Reference/note |
|------------------|-----------------------------|----------------|
| Motivation       | Low = 1                     | Stay in bed at least half the day due to health |
| Self-rated health| Excellent = 0, good = 0.25, fair = 0.5, poor/can’t say = 1 | |
| Cognition        | Dementia = 1, mild cognitively impaired = 0.5, delirium = 1, agitation = 1, delusions/hallucinations = 1 | |
| AMTS             | 6 or less = 1, >6 = 0       | The abbreviated mental test score |
| Emotional state  | Anxiety = 1, recent bereavement = 1, depression = 1, fatigue = 1 | |
| Sleep            | Poor or disrupted = 1, daytime drowsiness = 1 | |
| Speech           | Impaired = 1                | |
| Hearing          | Impaired = 1                | |
| Vision (with glasses) | Impaired = 1     | |
| Hemiparesis      | Weak arm = 1, weak leg = 1  | |
| Grips strength   | Weak = 1                    | The force of the dominant hand (average of three measurements) measured by the electronic grip strength scale (model EH101) |
|                  | (on non-hemiplegic side)    | |
| Weight           | Underweight = 1, obese = 1, slightly overweight = 0 (underweight: BMI < 18.5; obese BMI ≥ 28) | The 2013 People’s Republic of China Health Industry Standards |
| Weight change    | Loss = 1, significant gain = 1 | Change more than 5 kg in last year |
| Appetite         | Poor = 1, fair = 0.5, normal = 0 | |
| Continence       | Bowels incontinent = 1, bladder incontinent / catheter = 1 | |
| Medical history  | Hypertension, asthma/chronic obstructive lung disease, stroke/transient ischemic attack, angina/myocardial infarction, heart failure, diabetes, active cancer, alcohol excess, pressure sores, hip fracture, osteoarthritis/osteoporosis, Parkinson’s disease, first other medical problem, second other medical problem | Refer to medical record |
| (scoring 1 point each) | | |
| No. of medications in 24 h | 0–4 = 0, 5–9 = 1, 10–14 = 2, 15–19 = 3, 20–24 = 4, >25 = 5 | |
| Transfers        | Dependent = 1, assistance = 0.5 | Transfer from bed to other place |
| Walking          | Dependent = 1, assistance = 0.5 | |
| Movements slow   | Yes = 1                     | |
| Sitting balance  | Impaired = 1                | |
| Falls in the last 6 months | 3 or more = 1 | |
| Feeding          | Dependent = 1, assistance = 0.5 | |
| Washing          | Dependent = 1, assistance = 0.5 | |
| Could manage own medications | Dependent = 1, assistance = 0.5 | Help taking medicine |
| Could manage own finances | Dependent = 1, assistance = 0.5 | Help with finances |

FI: frailty index; BMI: body mass index.
*Deficits counted and cut points for the modified-Krishnan’s FI.

in which case appointed relatives signed the consent agreement. First, we remeasured the inter-rater reliability of the modified-Krishnan’s FI. Two different examiners blinded to each other administered the FI. The assessments were always administered 2 days apart before the operation. Then, the researcher completed the survey based on the

Table 1. Modified-Krishnan’s FI.*
The mean modified-Krishnan’s FI and CSHA-FI were 0.43 (0.09) in patients who died and was 0.27 (0.10) in patients who were alive at a 3-month follow-up after surgery. The sample size calculation was \[ n = \frac{2(\tau + \gamma)}{\sigma_2^2} 2 \times (1.96 + 1.282) 2 \times 0.00905/0.0256 \approx 7. \]

The overall postoperative mortality at a 3-month follow-up was about 6%, a total of 128 patients (7/0.06 \times 1.1) were needed to find significant difference including a 10% loss ratio of follow-up. Epidata 3.1 (Odense M, Denmark, Europe) was used to create a database in which all data were recorded by two people who were blind to the study. The SPSS 23.0 package was used for statistical analysis. The inter-rater reliability and Cronbach’s \( z \) coefficient were calculated for the scale’s reliability. The receiver operating characteristic (ROC) curves were used to depict the score distribution in the modified-Krishnan’s FI and in the CSHA-FI and to predict the postoperative mortality. The area under the curve (AUC) was calculated. The optimal predictive value was determined by the maximum value of the Youden index. \(^{18}\) The corrected diagnosis index (Youden index) equals the variation between the corresponding sensitivity and (1-specificity). The maximal cutoff point of the Youden index was set as the optimal predictive value. The Pearson correlation coefficient method was used to determine the correlations between the two FI scales and the JOA and FRS scores.

**Results**

The mean age of the 130 patients included was 77.5 \( \pm \) 8.5 years, with 43 (33%) male and 87 (67%) female participants. Before the fracture, 65 (50%) patients had an ADL\(^9\) of no dependence (Barthel index (BI): 100), 52 (40%) mild dependence (BI: 61–99), 11 (8.5%) moderate dependence (BI: 41–60), and 2 (1.5%) severe dependence (BI: 0–40). The median LOS was 17 (interquartile range (IQR): 11–19) days. The median time until discharge after operation was 13 (IQR: 8–15) days. The overall results at the postoperative 3-month follow-up are shown below: 7 (5.4%) patients died, 4 (3.1%) patients had fallen outside of hospital, 5 (3.8%) patients were readmitted to the hospital, and 103 (79%) patients experienced postoperative complications. The mean modified-Krishnan’s FI and CSHA-FI were 0.29 \( \pm \) 0.09 and 0.24 \( \pm \) 0.06, respectively. The FI cutoffs at 0.25 and 0.4\(^{12,20}\) divided this cohort of patients into low, medium, and high groups. By using modified-Krishnan’s FI, 50 (39%) of patients have low, 65 (50%) medium, and 15 (12%) high FI. By using CSHA-FI, 82 (63%) of patients have low, 47 (36%) medium, and 1 (0.8%) high FI. The reliability of the modified-Krishnan’s FI revealed that the inter-rater reliability for the total FI is strong (\( R = 0.92 \)), the alpha confidence coefficient is 0.725, the Kaiser–Meyer–Olkin value is 0.656, and the Bartlett test shows \( p < 0.001 \). The variables are divided into 10 common items and show a relatively good correlation between the score for each variable and total score.

**Comparison of the two FIs in predicting postoperative mortality**

The AUCs of modified-Krishnan’s FI (AUC = 0.856; 95% confidence interval (CI) = 0.767–0.945) and the CSHA-FI (AUC = 0.793; 95% CI = 0.652–0.934) were used to compare the effectiveness in predicting patient mortality, \( p = 0.002 \) and 0.009, respectively. They were statistically significant for the prediction of postoperative mortality. Moreover, the AUCs of modified-Krishnan’s FI was bigger than that of the CSHA-FI. According to the ROC curve (Figure 1), the optimal predicting points were 0.335 for modified-Krishnan’s FI (with a sensitivity of 100% and a specificity of 70%) and 0.28 for the CSHA-FI (with a sensitivity of 86% and a specificity of 78%).
Comparison of the two FIs in predicting postoperative functional recovery of the hip

The mean JOA score was 67.33 ± 18.21. The Pearson correlation coefficient method was used to analyze the correlations between the modified-Krishnan’s FI or the CSHA-FI and the JOA score. It concluded that the modified-Krishnan’s FI was negatively correlated with the JOA score (R = -0.249, p = 0.005), while the correlation between the CSHA-FI and the JOA score was not statistically significant (R = -0.125, p = 0.170; Figure 2).

Comparison of the two FIs in predicting postoperative recovery of daily activities

The mean FRS score was 65.92 ± 22.79. The Pearson correlation coefficient method was used to analyze the correlations between the modified-Krishnan’s FI or the CSHA-FI and the FRS score. It concluded that the modified-Krishnan’s FI (R = -0.415, p < 0.001) and the CSHA-FI (R = -0.332, p < 0.001) were significantly correlated with the FRS score (Figure 3).

Discussion

This study, which used two FIs to evaluate the frailty level of the elderly hip fracture patients, demonstrated that a high percentage of the subjects were frail which can be established preoperatively. The FIs were associated with the outcomes of elderly patients with hip fracture and may be used to predict the postoperative rehabilitation effect.

In recent years, frailty has become a popular measure in the field of geriatric medicine abroad to predict the possibility of adverse outcomes in the elderly, including falls,21 loss of ability,22 postoperative complications,23,24 entrance into institutional facilities,23–25 and mortality.5,25,26 The predictive results can provide references for clinical diagnosis and treatment.27 There are more than 20 assessment tools for frailty that have been used worldwide. One of the two most commonly used tools was the frailty phenotype28 and the FI.20 The frailty phenotype required assessing walking speed, so it is not suitable for assessing hip fracture patients. The number of variables used to construct an FI scale may vary between 30 and 70 items in most of the studies.8,10,26 Krishnan’s FI has an appropriate number of items and can be used for evaluating hip fracture patients, but the assessment of some of the cutoff points and self-evident deficits were uncertain. We clarified the needed detailed information for these indicators and restested the FI. Good inter-rater reliability and Cronbach’s α coefficient, and acceptable constructive validity suggest good reliability of modified-Krishnan’s FI. The clinical suitability of this FI is clear and is close to that reported in a previous study.4 Because partial deficits are available in the electronic medical record and we use a table-based sheet that automatically calculates the final FI, the scale was completed in approximately 10–15 min.

In this study, the results concluded that the modified-Krishnan’s FI and the CSHA-FI were effective in the prediction of patient mortality. Moreover, the predictive validity of modified-Krishnan’s FI was superior to that of
the CSHA-FI. Some international studies have proposed dividing the extent of frailty into low, moderate, and severe frailty by index scores of 0.25 and 0.4. However, to our knowledge, the optimal point of the FI scale for predicting postoperative mortality in hip fracture has not been reported. In this study, we found that when the preoperative modified-Krishnan’s FI was greater than 0.335, the probability of mortality was higher. Medical providers should sufficiently communicate with patients and their families to explain the patient’s condition and prognosis and to allow them to fully understand the potential risks. Moreover, the frailty assessment may help in prescribing specific interventions, including those active treatments of comorbidities, targeting physical exercise, and maintaining good nutritional status, and the application of the acupressure protocol to relieve the patient’s preoperative frailty, improve the ability to respond to surgical stress and to reduce mortality.

In addition, we found that modified-Krishnan’s FI was negatively correlated with the JOA value ($R = -0.249, p = 0.005$). The association of CSHA-FI with postoperative FRS did not reach statistical significance ($p = 0.170$). In terms of the postoperative recovery of daily activities, both modified-Krishnan’s FI and the CSHA-FI were correlated with the FRS score. Moreover, the correlation of modified-Krishnan’s FI with the FRS was bigger than that of CSHA-FI. As the FI score increased, the postoperative JOA value and FRS score tended to be lower, and the recovery of hip function and daily activities was accordingly poor. Based on the analysis of the two FIs, this study found that the modified-Krishnan’s FI was associated more consistently than the CSHA-FI with the recovery of hip function and daily activities 3 months postoperatively. The reason is likely that the deficits of modified-Krishnan’s FI more accurately evaluate the cognition, medical history, and physical function of elderly patients with hip fracture. However, the items for assessing coexisting and previous diseases and signs accounted for a larger proportion of the CSHA-FI, thus reducing the effects of the items for cognitive and functional evaluation. Therefore, the CSHA scale cannot predict the prognosis as accurately as can modified-Krishnan’s FI.

The limitation of this study is that the CSHA-FI is well validated and has been reported in many study populations, but modified-Krishnan’s FI has only been reported to be beneficial for predicting mortality in patients with hip fracture. It is easily conceived that modified-Krishnan’s FI has a better predictive value than CSHA. Another limitation is that only a few fatal cases were observed; thus, there were not enough to make a mortality prediction statement for the comparison of the two FIs. Future research efforts should increase the sample size and prolong the follow-up time in a multicenter study. Nevertheless, our study has some strength, including its prospective design and low follow-up loss ratio, and we improved the robustness and feasibility of modified-Krishnan’s FI by defining detailed information for variables. In addition, we compare two frailty measures to predict the relation between preoperative FI and postoperative rehabilitation in elderly hip fracture.
In summary, this study concluded that the modified-Krishnan’s FI and the CSHA-FI were effective in the prediction of postoperative mortality. But the modified-Krishnan’s FI associated more consistently than the CSHA-FI with the recovery of hip function and daily activities at 3 months postoperatively. We believe that this scale is more suitable to utilize, both as a tool for risk stratification and as a measurement for identifying deficits that may be modifiable preoperatively and for predicting postoperative recovery capacity in hip fracture patients.

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Author contributions
The study concept and design were performed by the authors HR and LWY, acquisition of subjects and data by LWY and DLQ, analysis and interpretation of data by DLQ and WG, manuscript preparation by LWY and WG, and HR supervised the study.

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References
1. Aarden JJ, Van Der Esch M, Engelbert RHH, et al. Hip fractures in older patients: trajectories of disability after surgery. J Nutr Health Aging 2017; 21: 837–842.
2. Abraham DS, Barr E, Ostir GV, et al. Residual disability, mortality, and nursing home placement after hip fracture over 2 decades. Arch Phys Med Rehabil 2019; 100: 874–882.
3. Clegg A, Young J, Iliffe S, et al. Frailty in elderly people. Lancet 2013; 381: 752–762.
4. Krishnan M, Beck S, Havelock W, et al. Predicting outcome after hip fracture: using a frailty index to integrate comprehensive geriatric assessment results. Age Ageing 2014; 43: 122–126.
5. Patel KV, Brennan KL, Brennan ML, et al. Association of a modified frailty index with mortality after femoral neck fracture in patients aged 60 years and older. Clin Orthop Relat Res 2014; 472: 1010–1017.
6. Kistler EA, Nicholas JA, Kates SL, et al. Frailty and short-term outcomes in patients with hip fracture. Geriatr Orthop Surg Rehabil 2015; 6: 209–214.
7. Andreou A, Lasithiotakis K, Venianaki M, et al. A comparison of two preoperative frailty models in predicting postoperative outcomes in geriatric general surgical patients. World J Surg 2018; 42: 3897–3902.
8. Cooper Z, Rogers SO Jr, Ngo L, et al. Comparison of frailty measures as predictors of outcomes after orthopedic surgery. J Am Geriatr Soc 2016; 64: 2464–2471.
9. Vasu BK, Ramamurthi KP, Rajan S, et al. Geriatric patients with hip fracture: frailty and other risk factors affecting the outcome. Anesth Essays Res 2018; 12: 546–551.
10. Singh I, Gallagher J, Davis K, et al. Predictors of adverse outcomes on an acute geriatric rehabilitation ward. Age Ageing 2012; 41: 242–246.
11. Partridge JSL, Harari D, and Dhesi JK. Frailty in the older surgical patient: a review. Age Ageing 2012; 41: 142–147.
12. Rockwood K, Song X, MacKnight C, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005; 173: 489–495.
13. Onderc NT, Bovonratwet P, Ibe IK, et al. Discriminative ability for adverse outcomes after surgical management of hip fractures: a comparison of the Carlson comorbidity index, Elixhauser comorbidity measure, and modified frailty index. J Orthop Trauma 2018; 32: 231–237.
14. Searle SD, Mitnitski A, Gahbauer EA, et al. A standard procedure for creating a frailty index. BMC Geriatr 2008; 8: 24.
15. Imura S. The Japanese Orthopaedic Association: evaluation chart of hip joint functions. J Jpn Orthop Assoc 1995; 69: 864–867. (In Japanese with English translation.)
16. Takeda H, Kamogawa J, Sakayama K, et al. Evaluation of clinical prognosis and activities of daily living using functional independence measure in patients with hip fractures. J Orthop Sci 2006; 11: 584–591.
17. Zuckerman JD, Koval KJ, Aharonoff GB, et al. A functional recovery score for elderly hip fracture patients: I. development. J Orthop Trauma 2000; 14: 20–25.
18. BR. M. Application of SPSS (PASW) 17.0 in medical statistics. 5the ed. Beijing: Science Press, 2015.
19. Mahoney FI and Barthel DW. Functional evaluation: the Barthel index. Md State Med J 1965; 14: 61–65.
20. Rockwood K and Mitnitski A. Frailty in relation to the accumulation of deficits. J Gerontol A Biol Sci Med Sci 2000; 55A: 282–288.
21. Fang X, Shi J, Song X, et al. Frailty in relation to the risk of falls, fractures, and mortality in older Chinese adults: results from the Beijing longitudinal study of aging. J Nutr Health Aging 2012; 16: 903–907.
22. Morley JE, Malmstrom TK, and Miller DK. A simple frailty questionnaire (FRAIL) predicts outcomes in middle aged African Americans. J Nutr Health Aging 2012; 16: 601–608.
23. Dale W, Hemmerich J, Kamm A, et al. Geriatric assessment improves prediction of surgical outcomes in older adults undergoing pancreaticoduodenectomy: a prospective cohort study. Ann Surg 2014; 259: 960–965.
24. Makary MA, Segev DL, Pronovost PJ, et al. Frailty as a predictor of surgical outcomes in older patients. *J Am Coll Surg* 2010; 210: 901–908.

25. Hubbard RE, Eeles EM, Rockwood MR, et al. Assessing balance and mobility to track illness and recovery in older inpatients. *J Gen Intern Med* 2011; 26: 1471–1478.

26. Kojima G, Iliffe S, and Walters K. Frailty index as a predictor of mortality: a systematic review and meta-analysis. *Age Ageing* 2018; 47: 193–200.

27. Dent E, Kowal P, and Hoogendijk EO. Frailty measurement in research and clinical practice: a review. *Eur J Intern Med* 2016; 31: 3–10.

28. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; 56: M146–M156.

29. Serra-Prat M, Sist X, Domenich R, et al. Effectiveness of an intervention to prevent frailty in pre-frail community-dwelling older people consulting in primary care: a randomised controlled trial. *Age Ageing* 2017; 46: 401–407.

30. Chan CWC, Chau PH, Leung AYM, et al. Acupressure for frail older people in community dwellings – a randomised controlled trial. *Age Ageing* 2017; 46: 957–964.