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Characterising frailty in the clinical setting—a comparison of different approaches

SIR—The definition and measurement of frailty are areas of ongoing debate. Martin and Brighton [1] recently highlighted the need to consider the utility of frailty measures for the geriatrician in clinical practice and the public health planner as well as for the research gerontologist.

Fried and colleagues [2] reported an operational definition of frailty based on the presence of three or more frailty indicators: unintentional weight loss, slow walking speed, subjective exhaustion, low grip strength and low levels of physical activity. Using these criteria, frailty was predictive of poor outcomes including institutionalisation and death amongst participants of the Cardiovascular Health Study [2] and other large population samples [3].

Rockwood has advocated an alternative approach to Fried by considering frailty in relation to the accumulation of deficits, ‘the more things individuals have wrong with them, the higher the likelihood they will be frail’ [4]. Frailty Indices comprising different variables and applied to different populations increase with age and correlate strongly with mortality [5].

Each approach to frailty has strengths and weaknesses. Fried’s model has been praised for clinical reproducibility and coherency [6] but is criticised for adopting a unidimensional approach to a complex and multi-dimensional concept [7]. Frailty in a clinical context consists of more than just weakness and wasting [8]. The exclusion of mood and cognition indices is particularly controversial [6]. The mathematical properties of Rockwood’s Frailty Index are promoted as a strength [4] but may seem daunting to clinicians.

This lack of consensus on a standardised tool for frailty measurement motivated the development of a modified frailty score. Routinely performed measures requiring limited specialist training or equipment were chosen across a range of physiological and performance domains. Weight loss and low grip strength were retained from Fried’s frailty phenotype since each is an independent marker of poorer prognosis [9, 10]. Timed get-up-and-go was included as a measure of physical performance as it is reliable and correlates well with gait speed and Barthel Index [11]. Cognition was incorporated as this has strong face validity for inclusion in frailty measures [7].

Since frailty is considered to arise from diminished reserve capacity resulting in increased vulnerability to stressors [12], there are many potential physiological markers of the frail state. Approximately 30% of normal forced expiratory volume (FEV1) represents the threshold for adequate function and has been proposed as a marker of frailty [13]. Interestingly, a range of other systems (including myocardial oxygen consumption [14], vision [15] and hearing [16]) exhibit a 70% margin of loss before evidence of failure presents [17]. FEV1 was chosen as the fifth measure for the modified frailty score as it can be reliably and easily measured in older people [18] and is an independent predictor of mortality [19].

The first aim of this study was to operationalise Fried’s and Rockwood’s frailty assessment methods in clinical populations relevant to the practicing geriatrician. In addition, the modified frailty score was compared to existing approaches.

Methods

Three groups of patients were chosen to represent ‘frail’, ‘intermediate’ and ‘fit’ on a functional frailty spectrum. Thirty institutionalised patients with severe functional impairment
were recruited from Continuing Care wards in Cardiff, South Wales. All met National Health Service Continuing Care criteria for ongoing nursing and medical needs [20]. Forty community-dwelling patients with a history of falls referred to Day Hospital for rehabilitation and 40 independent age-matched participants comprised the ‘intermediate’ and ‘fit’ groups. Forty per cent of each group were male and all subjects were Caucasian.

The study was approved by the Local Research Ethics Committee. Written informed consent was obtained from participants or, for patients who lacked capacity to give fully informed consent, assent was obtained from next of kin. Capacity was assessed in 75 Continuing Care patients with consent and assent rates of 57 and 40%, respectively. Two of 42 Day Hospital patients approached declined to participate. Twenty-six independent older people (including three pairs of spouses) responded to poster advertisements in local shops, blocks of flats, the leisure centre and the hospital outpatient department. One early participant recruited 14 friends from her Church social group.

Frailty indicators were measured in all subjects by a single observer (REH). Maximal grip strength was measured on the dominant side with a Physiomed hydraulic hand held dynamometer. The 6-min walk [21] was used to measure walking speed, and subjective exhaustion was assessed using the energy and vitality domain of the Short-Form 36 (SF-36) questionnaire [22]. Physical activity levels were self-reported or reported by nursing staff for Continuing Care patients using a validated questionnaire [23], with one or two out of six representing low levels of physical activity. Timed get-up-and-go was recorded using standard protocol [11]. Cognitive function was measured using the Mini-Mental State Examination [24] and spirometry with a Microlab 3300 portable spirometer.

Sensory impairments, co-morbidities, Barthel Index scores and history of weight loss were self-reported by Day Hospital patients and independent older people and obtained from medical notes or nurse interview for Continuing Care patients.

As in Fried’s study, cut offs for positive frailty indicators were set at the lowest 20% of the independent older group which were, in this study, grip strength ≤16 kg, 6 min walking distance ≤210 m, energy and vitality score on SF-36 <40% and timed get-up-and-go ≥17 s. Other frailty indicators were based on previously reported levels of significance: MMSE of 24 or less [25], score of 11 or more for either depression or anxiety on the Hospital Anxiety and Depression Score [26] and Barthel Index score of 8 or less out of 20 [27]. Unrecordable grip strength, inability to walk and inability to rate exhaustion level were taken as positive frailty indicators.

For the Fried and modified frailty scores, presence of three to five indicators represented ‘frail’, one to two ‘pre-frail’ and zero ‘fit’. A total of 30 variables were collected for the Rockwood Frailty Index. Variables or ‘deficits’ represented conditions that accumulate with age and are associated with adverse outcomes, ranging in severity from death (e.g. cancer) to discomfort or disability (e.g. difficulty hearing) [28]. Deficits, therefore, included sensory and functional impairments, performance-based tests and co-morbidities (including asthma/chronic obstructive airways disease, hypertension, cerebrovascular disease, ischaemic heart disease, heart failure, diabetes mellitus, cancer, arthritis, osteoporosis, Parkinson’s disease, depression and dementia) (Table 1). Deficits were combined by adding them, 1 for each deficit that was present, 0 if absent. The index was the total deficits as a proportion of those counted (e.g. 6/30 = 0.20).

Data were analysed using the Statistical Package for Social Sciences (SPSS), version 12.0.2, and expressed as mean ± standard deviation. For categorical variables, percentages of patients in different groups were compared using chi-squared analysis and associations measured using Pearson’s correlation.

### Table 1. Frailty indicators used to operationalise Fried frailty phenotype, Rockwood Frailty Index and modified frailty score

<table>
<thead>
<tr>
<th></th>
<th>FRIED 5 indicators</th>
<th>ROCKWOOD 30 indicators</th>
<th>MODIFIED 5 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss &gt;5 kg in preceding year</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Grip strength ≤16 kg</td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Low levels of physical activity</td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>6 min walking distance ≤210 m</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Energy and vitality score on SF36 &lt;40%</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>MMSE score ≤24</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Timed get-up-and-go of ≥17 s</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>FEV1 ≤30% predicted</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Urinary incontinence</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Faecal incontinence</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Anxiety or depression score of 11 or more on Hospital Anxiety and Depression scale</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Barthel score of 8 or less</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Co-morbidities (maximum of 15)</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Subjective report of difficulty hearing</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Registered blind or partially sighted</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Falls (3 or more in preceding year)</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

- FRIED 5 indicators
- ROCKWOOD 30 indicators
- MODIFIED 5 indicators
Table 2. Completion of physical performance, lung function, strength, mood, cognition and functional status tests by subjects in each group

<table>
<thead>
<tr>
<th>Test</th>
<th>Independent old (N = 40)</th>
<th>Day hospital (N = 40)</th>
<th>Continuing care (N = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timed get-up-and-go</td>
<td>40</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>6 min walk</td>
<td>39</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>Lung function</td>
<td>40</td>
<td>40</td>
<td>16</td>
</tr>
<tr>
<td>Grip strength</td>
<td>40</td>
<td>40</td>
<td>26</td>
</tr>
<tr>
<td>Mini-Mental State Exam.</td>
<td>40</td>
<td>40</td>
<td>28</td>
</tr>
<tr>
<td>Examination</td>
<td>40</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>Hospital Anxiety and Depression score</td>
<td>40</td>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>

Results

Subjects ranged in age from 75 to 97 years with no significant difference in mean age between the three groups: Continuing Care 84.9 years (6.9), Day Hospital 84.2 years (4.9), independent older people 82.7 years (5.5) (P = 0.215).

Completion of physical performance, lung function, strength, mood, cognition and functional status tests is shown in Table 2.

Fried frailty status, Rockwood Frailty Index and the modified frailty score were each significantly different (P < 0.05) across the three groups (Table 3).

There was a high degree of correlation between the Fried score and Rockwood Frailty Index (r = 0.92, P < 0.01). The alternative multi-dimensional frailty score correlated significantly with both the Fried score (r = 0.93, P < 0.01) and Rockwood Frailty Index (r = 0.89, P < 0.01).

Discussion

In this small study, there were significant differences in Fried frailty score and Rockwood Frailty Index between three groups of patients who would be clinically distinguishable by geriatricians on a frailty spectrum. An alternative multi-dimensional frailty score correlated highly with both measures.

Performing assessments in different settings and the use of different methods for data collection were unavoidable limitations considering the populations studied. It would have been neither feasible nor justifiable to transport highly dependent Continuing Care patients to the Day Hospital for the purposes of research. Several steps were taken to reduce bias. All measurements were carried out by a single investigator, eliminating the confounder of inter-observer variation, and all assessments had standardised methods; none depended upon specialised equipment or technology available at one site and not the others. Medical diagnoses were obtained from hospital notes for Continuing Care patients but self-reported by independent older people and Day Hospital patients. Previous studies indicate that while medical records may underestimate symptom-based conditions such as osteoarthritis [29], the differences between physician documentation and self report for other chronic conditions are small with age, race and gender having no significant effect [29, 30].

The five alternative frailty measures—weight loss, low grip strength, slow timed get-up-and-go, MMSE ≤ 24 and FEV1 ≤ 30% predicted—are underpinned by the concept that frailty is multidimensional and manifests as decreased physiological reserve. This was a small study with development data only (the score has not been validated against adverse outcomes). No conclusions can be made regarding the potential of this alternative frailty score as a clinically meaningful measure of frailty.

Applying the Fried phenotype, 29 Day Hospital patients (72.5%) were defined as frail. Their ‘physical frailty’ and high risk of adverse outcomes may be under-recognised by the modified frailty score. However, a frailty measure that does not discriminate between hospitalised, highly dependent patients and community-dwelling older people has potential limitations. Frailty stereotyping may deny the latter group access to appropriate investigations and treatment [6] and compromise the precision of mortality prediction [31, 32].

In the Canadian Study of Health and Ageing [33], a Frailty Index was determined for 2,305 older people and each was assigned to one of seven categories on a Clinical Frailty Scale, ranging from ‘very fit’ to ‘severely frail’. This enables contextualisation of our study groups’ frailty index scores. Continuing Care patients (Frailty Index 0.49) were comparable to the ‘severely frail’ category (0.43) of the Clinical Frailty Scale. Independent Old (0.15) were between ‘well’ (0.12) and ‘well, with treated co-morbid disease’ (0.16). This seems clinically appropriate as selection criteria for this group did not exclude any co-morbidity. Day Hospital patients had a mean Frailty Index of 0.33 (0.08) which most closely correlates with the ‘moderately frail—help is needed with activities of daily living’ category on the Clinical Frailty Scale (0.36). Thus, the Frailty Index approach seems to have a good span of sensitivity and translate meaningfully from an epidemiological perspective to a small clinical study.

The assessment of physical performance across the full spectrum of frailty in older people posed important challenges. Some performance-based measures (particularly strength) have the advantages of valid quantification and potential for high precision [34]. However, reference ranges, particularly for the oldest old, are not well established [35]. Performance based data are frequently ‘missing’ in subjects who are ill [36] or frail [37]. In this study, none of 30 Continuing Care patients were able to undertake a 6-min walk or timed get-up-and-go, and grip strength could not be assessed in 4 (13.3%). Inability to perform any test was taken as a positive frailty indicator. However, many studies of performance-based tests exclude those who are unable to complete the test [38]. This is an important limitation of performance-based measures [39, 40] and highlights the need for a reliable and responsive frailty measure for the frailest old, with linearity between reference points even at the lowest end of the performance spectrum [41].

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In summary, while there were significant differences in each frailty measure across the three study groups, categorical approaches may lack discriminatory power at the moderate/severe end of the frailty spectrum. The generation of ‘missing’ performance data is a limitation of any potential frailty measure that needs explicit consideration. Rather than further epidemiological research studies, perhaps future work in this important field should focus on the utility and validity of frailty tools in clinical practice.

**Key points**

- In this small study, there were significant differences in the Fried frailty score and the Rockwood Frailty Index between three groups of patients who would be clinically distinguishable by geriatricians.
- The Rockwood Frailty Index and a modified frailty score were more discriminatory than the Fried phenotypic score at the moderate/severe end of the frailty spectrum.
- The assessment of physical performance in the frailest older people posed important challenges with many patients unable to complete the tests.

**Conflicts of interest**

The authors declare no conflicts of interest.

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**References**

Association between ankle muscle strength and limit of stability in older adults

SIR—Loss of balance and falls in the elderly constitute a major problem associated with human suffering as well as high costs for society [1]. Falls might occur during various daily activities, such as tripping or tangling the feet, reaching movements or bending [2]. Many of these activities are constrained by limits of stability (LOS). LOS can be described as the maximum distance a person can intentionally displace his/her centre of gravity, and lean his/her body in a given direction without losing balance, stepping or grasping. Accordingly, one’s LOS capacity is likely to be an important prerequisite for the successful planning and execution of movements such as using a step stool to reach into a high cabinet as well as bending over from standing position to pick up an object from the floor.

Ageing is associated with decreased LOS [3–5], muscle strength [6] and foot sensation [7]. Investigators have reported significant correlations between postural stability, quadriceps, ankle dorsiflexion and hand-grip strength [8–11], tibialis anterior latency [8] and functional clinical balance testing [12] among older adults. However, the relationships between lower-limb muscle strength and falls are unclear. Several studies show minimal or no differences in strength between fallers and non-fallers [13, 14] while others show no strength–falls relationships [15].

Cutaneous mechanoreceptors at the soles of the feet contribute to postural stability when standing [16]. Those with reduced foot sensation have a higher risk of falling [17] and greater instability [18]. Reduced foot sensation may contribute to reduced LOS, since older adults might not...