design, execution, analysis and interpretation of data, or preparation of the study.

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Failure to complete performance-based measures is associated with poor health status and an increased risk of death

Sir—Mobility impairment is common in elderly people, often leads to adverse outcomes [1–4] and is intertwined with frailty [5, 6]. Three types of standardised mobility assessments [self-reported, gait laboratory and performance-based measures (PBMs)] are used, and each has its own advantages and disadvantages, including variable feasibility. PBMs attempt to optimise the practicality of clinical and self-reported assessments, and the precision of the gait laboratory [7]. The Timed Up and Go (TUG) [8] and the Functional Reach (FR) [9] are used widely, [10, 11] but often cannot be used for a large proportion on whom the tests are attempted [12]. Such difficulty in undertaking the tests yields missing data, most frequently in those who are ill [13], or frail [14]. We therefore studied feasibility in PBMs and whether missing data were informative. We compared the characteristics of people from the clinical examination in the Canadian Study of Health and Aging-2 (CSHA-2) who were able to perform both the FR and TUG, with those who could not, and then

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tested the predictive validity of missing data for both these tests.

Methods

The CSHA is a representative, cohort study of Canadians aged 65+ in 1991–92 and followed up at 5 year (CSHA-2) and 10 year (CSHA-3) intervals [15]. The CSHA-2 clinical examination cohort used PBMs and included 2,305 subjects (1,431 women) from two groups: People who were screened negative for cognitive impairment (scoring > 77 on the Modified Mini-Mental State Examination—3MS [16]) at both CSHA-1 and CSHA-2 (n = 758) and others with possible cognitive impairment. The latter consisted of 210 who had been institutionalised at CSHA-1, 350 who had scored < 77 on the 3MS at CSHA-1 but had refused clinical examination and 987 who had newly screened positive at CSHA-2.

Vital and institutional status is known for all 2,305 participants, of whom 1,299 (56.4%) were alive at CSHA-3. Here, we excluded only 60 people whose PBM data were missing for unknown reasons. Of those originally classified as having missing data, 884 could not complete and 37 refused to complete both PBMs. Another 185 were not offered the tasks due to lack of space or equipment, while 30 had more than one reason for not completing both PBMs.

The FR score [9] was calculated as the average of three trials. We defined three ‘able-to-complete’ groups: FR ≥ 10 inches (25 cm), FR1; FR<10 inches, FR2; FR<6 inches (15 cm), FR3. (People who had missed even one trial were scored as missing.) For the TUG score [8], we used the second of two trials. Here too, we defined three ‘able’ subgroups, corresponding to tertiles: TUG<10 s, TUG1; TUG>10 s ≤ 14 s, TUG2; TUG>14 s, TUG3.

We grouped people with missing data as either ‘Could not complete one test’ or ‘Could not complete both tests’. We measured frailty using the FI-CGA, a frailty index based on a standard Comprehensive Geriatric Assessment (CGA) that defines 7 levels of a fitness-frailty continuum [17, 18]. We also used the Geriatric Depression Scale (GDS) [19] and, to measure co-morbidity, the Cumulative Illness Rating Scale (CIRS) [20] was used.

Categorical-categorical and categorical-continuous variable comparisons were made using chi-square and ANOVA, respectively. The risk of adverse outcomes was assessed using survival analysis with Cox regression modelling and Kaplan-Meier curves.

Results

Almost half (49.3%) of the respondents could not perform one or both PBMs (Table 1). As with those whose performance on both the FR and TUG was impaired, patients with missing data on either or both the FR/TUG were more likely to be older women and to have worse scores for mood, cognition, function and co-morbidity (Table 1).

Cox regression models, adjusted for age, sex and education, suggested that people who could not perform

either or only one PBM were at a higher risk of death (3.07, 95% CI = 2.37–3.98; 2.26, 1.70–3.01, respectively) than those who could perform either at the best tertile of performance. There was no significant relationship between the inability to perform either or both measures and the risk of institutionalisation. Kaplan-Meier curves confirm the dose–response relationship with respect to death (Figure 1) and the absence of a significant relationship with respect to institutionalisation (data not shown).

Discussion

In this study of elderly Canadians, almost half could not complete either of the two performance-based measures, because of inability, refusal, or lack of equipment or space. People with such missing data were frailer, being more cognitively impaired, functionally disabled and having a lower mood and more illnesses. They had higher rates of death over 5 years of follow-up.

Our data must be interpreted with caution. The decision about whether an individual could not perform the test, or did not have sufficient room to do so, reflects not just the judgment of the subject, but also that of the research
On the other hand, it contains a large number of normal representative, as it targets people with cognitive impairment. The CSHA is population-based, the clinical sample is not.

The measurement properties of PBMs exclude people who falls, are not available. We did not use the original cut-points for grading performance is used.

PBMs were introduced as a means of making risk assessment more precise than conventional clinical or self-report measures [21], and are even now advocated as essential to defining frailty [22]. However, in three recent investigations of mobility in the elderly, the proportion with missing data varied widely from 1.0 to 19.5% for the FR and 0.7 to 51% for the TUG [10, 13, 23]. Moreover, many studies of the measurement properties of PBMs exclude people who are not well enough to perform the tests!

Another way to assess mobility is to observe the usual performance, rather than task performance. For example, the Hierarchical Assessment of Balance and Mobility (HABAM) observes simple movement in routine clinical encounters [24]. It is also structured so that the variable movements of even bedfast patients (e.g. ‘cannot move off pressure points’; ‘can push to sit up’) can be graded. Missing data are often much less of a problem with such a measure [25]. Clinical usefulness and not just reliability, validity and responsiveness, must be considered in the selection of instruments in this important area of inquiry if we are not to obscure useful information as missing data.

**Key points**

- What is known about this topic: performance-based measures allow for graded estimates of mobility and balance, but are often infeasible with elderly people.
- What this paper adds: missing data due to infeasibility or refusal is informative. Here, those with missing data on either one of the TUG or FR had worse outcomes than those with poor performance, and those with missing data for both had the worst outcomes.

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**Conflict of interest**

We declare that we have no conflict of interest.

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