Comparative analysis of frailty identification criteria on continuous non-invasive neurocardiovascular signals during an active stand test in The Irish Longitudinal Study on Ageing (TILDA)

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BACKGROUND

Frailty is a distinctive health state related to acceleration of biological ageing in which multiple body systems disproportionately lose their in-built reserves. Older people living with frailty are at higher risk of adverse health outcomes when their physiology is suddenly challenged.

The act of standing up quickly from lying down (active stand) requires rapid adaptations across physiological systems, some of which can be continuously measured using non-invasive devices. It is known that different frailty identification tools capture different functional profiles (e.g., degree of disability) and long-term risks (e.g., mortality), but there is paucity of data as to how different frailty tools capture differences in continuous physiological signals during an active stand.

AIM

We compared frailty by three different identification criteria in their continuous cardiovascular and neurovascular responses to an orthostatic active stand test.

METHODS

We used data from wave 3 of TILDA and identified four mutually exclusive groups: frail only by Fried's physical Frailty Phenotype (FP), 32-item Frailty Index (FI), and the Clinical Frailty Scale (CFS) classification tree; and a fourth group where participants were not frail by any of these tools.

Six continuous non-invasive physiological signals were collected during the active stand test; three in the cardiovascular domain: systolic (SBP), diastolic (DBP) blood pressure, and heart rate (HR), using a digital artery photoplethysmography device; and three in the neurovascular domain: left frontal lobe cerebral oxygenation (Oxy), deoxygenation (Deoxy) and tissue saturation index (TSI), using near-infrared spectroscopy (NIRS). Continuous physiological signals were visualised across frailty groups and statistically compared using one-dimensional statistical parametric mapping (SPM).

RESULTS

A total of 1170 participants (mean age 63.5 years, 51.3% women) were included: 25 frail only by FP, 102 by FI, 43 by CFS, and 1000 by none (Figure 1).

As expected, all frail participants were more comorbid, more medicated, and more physically limited than non-frail participants, but these differences were most accentuated for the FI classification. In the pairwise comparison, only the frail by FI reported a significantly higher proportion of post-stand dizziness compared to the non-frail group (p=0.010) (Table 1). Figure 2 provides a visualisation of the active stand time-series plots.

SPM analyses (Figure 3) revealed that only the frail by FI had significantly different signals ($p < 0.05$) compared to the non-frail group: lower HR between 5-15 s post-stand, lower SBP/DBP between 15-40 s post-stand, and lower TSI around 20 s post-stand.

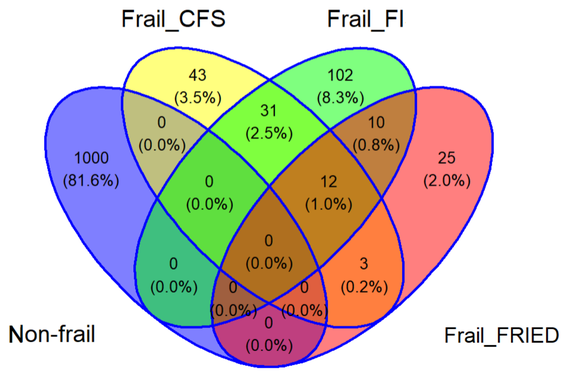

Figure 1: Venn diagram of the study population.

Characteristic	Non-Frail	Frail-CFS	Frail-FI	Frail-FP	p overall	p CFS-NonFrail	p FI-NonFrail	p FP-NonFrail
Mean age, years	62.7	64.1	69.6	69.8	≤0.001	0.182	≤0.001	≤0.001
Male sex (%)	0.5	0.5	0.3	0.6	0.009	0.871	0.001	0.871
Mean number of chronic diseases	0.7	1.9	3.0	1.8	≤0.001	≤0.001	≤0.001	≤0.001
Mean number of cardiovascular diseases	0.6	0.9	2.4	1.3	≤0.001	0.058	≤0.001	≤0.001
Mean number of regular medications excluding supplements	1.1	2.4	5.6	3.2	≤0.001	≤0.001	≤0.001	≤0.001
Mean number of physical limitations	0.8	3.7	4.9	2.1	≤0.001	≤0.001	≤0.001	≤0.001
Mean baseline SBP, mmHg	139.8	141.3	145.6	140.2	0.138	0.459	0.024	0.734
Mean baseline DBP, mmHg (SD)	77.0	75.3	74.6	74.5	0.081	0.352	0.017	0.409
Mean baseline HR, bpm	64.7	63.8	67.6	70.3	0.006	0.598	0.020	0.008
Mean baseline TSI	71.9	71.0	71.8	71.0	0.579	0.250	0.670	0.450
Mean baseline Oxy	29.1	26.7	27.0	27.6	0.099	0.181	0.041	0.363
Mean baseline Deoxy	10.8	10.3	10.1	10.4	0.375	0.350	0.130	0.710
Dizziness on standing (%)	25.5	34.9	37.3	24.0	0.044	0.168	0.010	0.168

Table 1: Demographic and clinical characteristics of the groups included in the study.

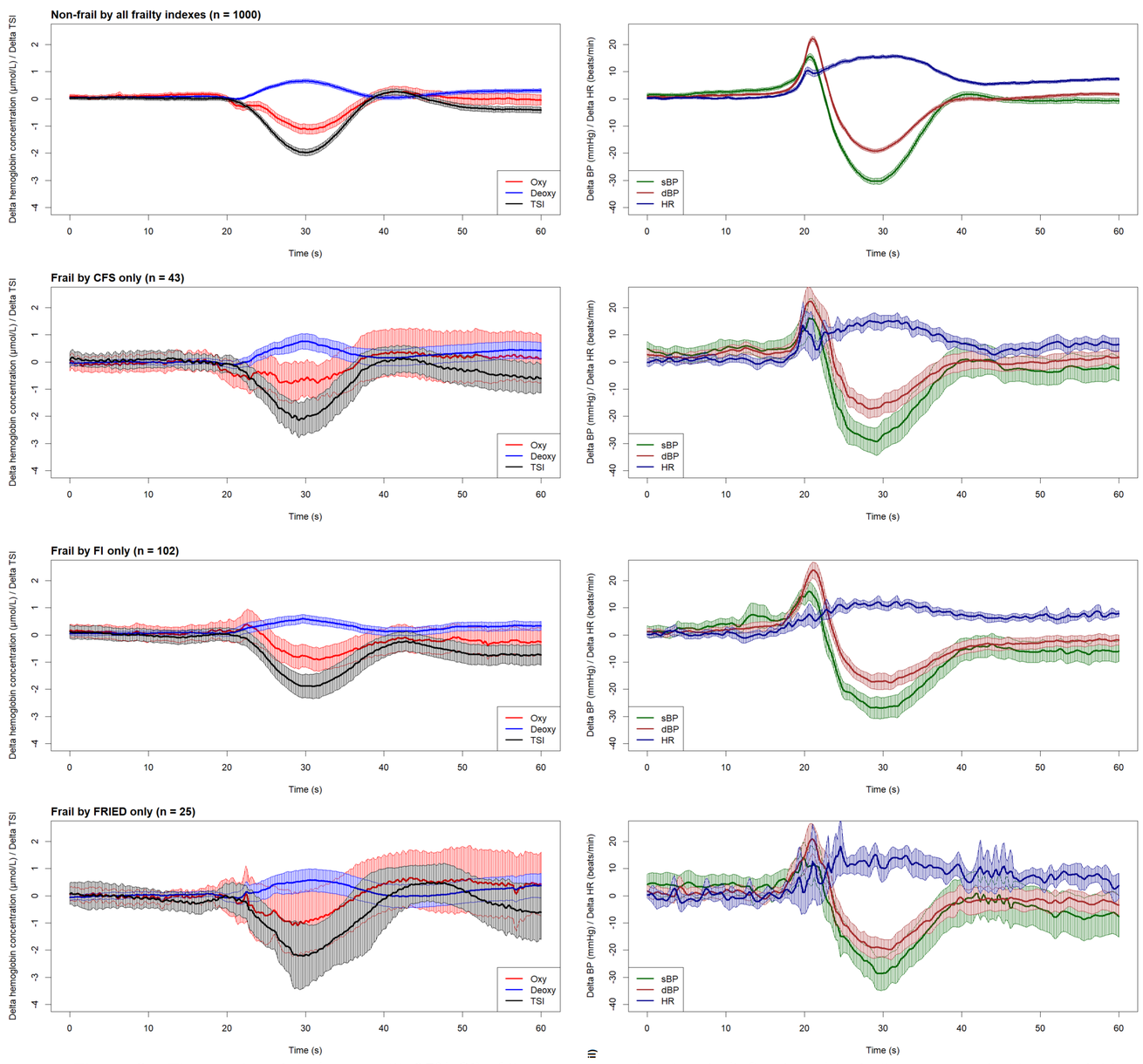

Figure 2 : Time-series plots (mean with 95% CI) of the neurovascular signals (left column) including oxygenated haemoglobin concentration (Oxy), deoxygenated haemoglobin concentration (Deoxy) and tissue saturation index (TSI); and cardiovascular signals (right column) including systolic blood pressure (sBP), diastolic blood pressure (dBP) and heart rate (HR).

Figure 3: Results of the SPM analyses. Shaded grey areas denote a statistically significant difference ($p < 0.05$)

CONCLUSION

Different frailty identification tools may capture different physiological responses to an orthostatic stress. The FI showed the best discrimination in this analysis.

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