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Original Article

The SHARE Frailty Instrument for Primary Care was Associated with Sarcopenia, as Measured by Bioelectrical Impedance, in Falls Clinic Attendees

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Abstract

Objective: This study aimed to assess the association between measures of frailty phenotype (FP) and malnutrition, and sarcopenia measured by bioelectrical impedance analysis (BIA), in individuals aged 50 and above attending an outpatient falls clinic. **Methods**: The Survey of Health, Ageing and Retirement in Europe Frailty Instrument (SHARE-FI) gauged FP status, while nutritional assessment relied on the Mini Nutritional Assessment-Short Form (MNA®-SF). Body composition, specifically appendicular skeletal muscle mass (ASMM), was determined through TANITA® DC-430MA BIA. Multivariable binary logistic regression models were used to predict pre-frailty or frailty based on SHARE-FI and at-risk of malnutrition or malnutrition based on MNA®-SF. **Results**: Out of the 123 participants (68 women, 55 men), 56.1% were classified as robust, 27.6% as living with pre-frailty, and 16.3% as living with frailty according to SHARE-FI. MNA®-SF results were available for 116 patients, with 54.3% categorised as normal, 39.7% at risk of malnutrition, and 6.0% as malnourished. Among the 118 patients who underwent BIA, ASMM was independently associated with pre-frail/frail status, but there was no significant association between abnormal MNA®-SF and sarcopenia. **Conclusion**: SHARE-FI, a modified FP tool, demonstrated an independent association with sarcopenia as measured by BIA.

Keywords: Frailty, Sarcopenia, Nutrition, Body Composition, Bioelectrical Impedance Analysis

Introduction

Frailty is a geriatric syndrome defined as progressive age-related decline in physiological reserves leading to vulnerability to stressors. Living with frailty increases the risk of adverse health outcomes in older adults including falls, disability, morbidity and mortality[1]. While various operationalisations of frailty have been proposed for clinical practice and research, one of the most utilised is the physical frailty phenotype (FP) originally proposed by Fried et al.[2]; this identifies frailty when three or more of the following are present: exhaustion, unexplained weight loss, weakness (by grip strength), slowness (by gait speed), and low physical activity; and pre-frailty is identified when one or two are present[2].

In their proposed 'cycle of frailty', Fried et al. identified sarcopenia as a key pathophysiological driver of the FP, in addition to chronic malnutrition, amongst others[2]. Specifically, inadequate intake of protein and energy, as well as micronutrient deficiencies, increase the risk of weight loss and sarcopenia via negative energy and nitrogen balance. Low muscle strength (e.g., by grip strength) is an indicator of probable sarcopenia; low muscle quantity and/or quality confirms the diagnosis of sarcopenia; and physical performance (e.g., gait speed) is evaluated to assess the severity of sarcopenia[3]. Muscle quantity can be measured

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by Dual-energy X-ray absorptiometry (DXA), Magnetic Resonance Imaging or Computed Tomography, but these radiological techniques are often not routinely available in clinical practice. An alternative is the measurement of appendicular skeletal muscle mass (ASMM) by bioelectrical impedance analysis (BIA)[3], which often generates additional estimates of body composition. When addressing chronic malnutrition in adults, various validated tools are available for both clinical practice and research purposes[4].

The identification of the FP is important for the management of older individuals with a history of falling[2,5,6], where sarcopenia[7] and malnutrition[8] may be underlying factors. Therefore, we aimed to study the association between the FP, malnutrition, and sarcopenia by BIA in falls clinic attendees.

Materials and Methods

Participants and setting

We included a pilot sample of outpatients who attended the Falls and Syncope Unit (FASU) at the Mercer's Institute for Successful Ageing (MISA) in St. James's Hospital, Dublin, Ireland, between 19th November 2021 and 25th November 2022. FASU is a specialist clinic that uses non-invasive neuro-cardiovascular technologies to provide expert assessment of patients referred with dizziness, pre-syncope, syncope or falls[9]. Inclusion criteria were age of 50 years or older; ability to provide written informed consent; and independent mobility (with or without aid). Patients with pacemakers and battery-operated implantable devices were excluded from BIA assessment, but we did not exclude patients with other implants or prostheses.

Assessment

For descriptive purposes, we collected age (years) and sex; BMI (kg/m^2); morbidity burden as per Cumulative Illness Rating Scale-Geriatric (CIRS-G) score[10]; polypharmacy as a patient regularly taking 5 or more prescribed medications, as most commonly defined in the literature[11]; and a history of at least one fall in the past year, as defined by the World Health Organization (WHO) as an event resulting in a person coming to rest inadvertently on the ground, floor, or another lower level[12].

The Survey of Health, Ageing and Retirement in Europe Frailty Instrument (SHARE-FI)[13] was used to identify FP status, separately for men and women. SHARE-FI is based on a modified FP approach (fatigue, low appetite, weakness by handgrip strength, difficulties walking or climbing stairs, and low physical activity). Accordingly, patients were categorised as robust, and living with pre-frailty or frailty. The SHARE-FI grip strength test was performed using a Jamar® hydraulic hand dynamometer in the seated position (maximum of four measurements, two in each hand).

Nutrition status was assessed by the Mini Nutritional Assessment-Short Form (MNA®-SF)[14]. The MNA®-SF is a validated tool designed to identify older patients who are malnourished or at risk of malnutrition. It evaluates six domains: decrease in food intake, weight loss, mobility, psychological stress/acute disease, neuropsychological problems, and BMI (or calf circumference if BMI is not available). Three categories are identified: normal, at risk of malnutrition, and malnutrition.

Body composition by BIA was measured with the TANITA® DC-430MA medically accredited device (Tanita Europe, Amsterdam, The Netherlands)[15]. Participants stood barefoot on the scale and were asked to remove their outerwear and empty their pockets, and 0.5kg was entered as a standard tare value for clothing. We calculated ASMM (kg) by applying Sergi's formula[16], as described elsewhere[17]. As per EWGSOP2 criteria, confirmed sarcopenia cut-off points for muscle quantity were <20 kg for ASMM in men and <15 kg for ASMM in women[3]. We also noted the automated readings of whole-body fat mass (FM, kg), transformed it to FM as % of body weight, and calculated the prevalence of obesity by fat percentage (>25% in men, >35% in women)[18]. In addition, we recorded the estimated basal metabolic rate (BMR) in kilocalories (kcal).

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows (Version 26.0., Armonk, NY: IBM Corp). Descriptives were given as mean and standard deviation (SD) for continuous variables, and count and percentage (%) for categorical variables. The two-tailed Spearman's rank correlation coefficient (r_s) was utilised to assess the association between ordinal and continuous variables. The Chi-square for trend statistic was used to assess the association between frailty status (ordinal variable) and binary variables.

Subsequently, SHARE-FI frailty status was transformed from a 3-level ordinal variable into a binary variable: robust participants were coded as "0", and participants living with pre-frailty or frailty as "1". Analogously, MNA®-SF was dichotomised into normal versus at risk of malnutrition/malnourished. The purpose the latter was to assess the association between an abnormal MNA®-SF and sarcopenia, considering the previous correlation found between MNA®-SF and SHARE-FI[19]. For each of those two dependent variables, two multivariable binary logistic regression models were computed to assess the following independent variables: Model 1: age, sex, sarcopenia by ASMM, obesity by fat percentage, and the interaction term between the latter two; Model 2: age, sex, ASMM, fat percentage, and the interaction between the latter two. For each independent variable, we obtained odds ratio (OR) with a 95% confidence interval (CI). A P-value of less than 0.05 was considered statistically significant throughout.

	Robust n=69 (56.1%)	Living with pre-frailty n=34 (27.6%)	Living with frailty n=20 (16.3%)	*P*	*n*
Mean age (SD) years	68.6 (9.9)	74.2 (10.9)	70.5 (11.1)	0.082^	123
Female sex %	43.5	70.6	70.0	0.008#	123
Mean BMI (SD) kg/m^2	26.6 (3.7)	24.8 (4.7)	27.8 (5.8)	0.409^	123
Mean CIRS-G score (SD)	6.0 (4.0)	7.3 (4.0)	9.4 (2.9)	<0.001^	123
Polypharmacy %	40.6	61.8	75.0	0.003#	123
At least 1 fall in the past year %	47.8	61.8	75.0	0.022#	123
Mean MNA®-SF score (SD)	11.3 (1.5)	10.0 (2.1)	10.5 (1.4)	<0.001^	116
Mean BMR (SD) kcal	1583.7 (321.9)	1328.4 (218.8)	1409.2 (267.8)	0.001^	118
Mean ASMM (SD) kg	22.0 (4.7)	18.9 (3.6)	19.5 (3.9)	0.003^	118
Confirmed sarcopenia by ASMM %	6.1	24.2	31.6	0.002#	118
Mean fat mass (SD) kg	23.8 (7.7)	21.9 (9.0)	27.2 (11.6)	0.940^	118
Mean fat percentage (SD)	30.5 (7.6)	32.1 (7.9)	35.7 (8.9)	0.032^	118
Obesity by fat percentage (>25% men, >35% women) %	57.6	51.5	78.9	0.224#	118

n Number, SD Standard Deviation, BMI Body Mass Index, CIRS-G Cumulative Illness Rating Scale for Geriatrics, ASMM Appendicular Skeletal Muscle Mass, MNA®-SF: Mini Nutritional Assessment Short-Form, BMR: basal metabolic rate. ^2-sided Spearman's rank correlation coefficient, #Chi-square for linear trend.

Table 1. Participant characteristics by SHARE-FI frailty status.

Results

A total of 123 patients were recruited (68 women and 55 men). According to SHARE-FI, 69 patients were identified as robust (56.1%), 34 as living with pre-frailty (27.6%), and 20 with frailty (16.3%). MNA®-SF was available for 116 patients: 63 normal (54.3%), 46 at risk of malnutrition (39.7%), and 7 malnourished (6.0%). SHARE-FI and MNA®-SF were significantly correlated (r_s=0.30, P=0.001). Characteristics of the study sample, by SHARE-FI frailty category, are shown in Table 1. Higher frailty was associated with female sex, higher morbidity, more frequent polypharmacy, more frequent falls in the past year, lower MNA®-SF score, and lower BMR.

BIA was conducted in 118 patients (96%). There was a significant inverse association between frailty status and mean ASMM, and a significant direct association between frailty and confirmed sarcopenia by ASMM. Fat percentage significantly increased with frailty, but there was no association between frailty and obesity by fat percentage (Table 1).

Table 2 shows the results of the binary logistic regression models predicting pre-frailty/frailty status (n=118). In Model 1, significant variables independently associated with pre-frailty/frailty were female sex (OR 3.38, 95% CI 1.45 – 7.87, P = 0.005) and sarcopenia by ASMM (OR 7.69, 95% CI 1.30 – 45.67, *P*=0.025). In Model 2, ASMM (OR 0.46, 95% CI 0.25 – 0.87, *P*=0.016) and weakly, the interaction ASMM * fat percentage (OR 1.02, 95% CI 1.00 – 1.04, *P*=0.042) were significant.

In n=111, none of the body composition variables considered predicted abnormal MNA®-SF (Table 3). Specifically, sarcopenia was not independently associated with abnormal MNA®-SF.

Discussion

In this cross-sectional observational study, we investigated the association between a measure of the FP, abnormal nutritional status, and sarcopenia by BIA in falls clinic attendees. The primary finding is that living with physical pre-frailty or frailty as measured by SHARE-FI was significantly and independently associated with sarcopenia measured by BIA, while abnormal nutritional status, as assessed by the MNA®-SF, was not associated with sarcopenia.

The observed association between SHARE-FI and MNA®-SF observed in our study is consistent with previous observations. In an observational study carried out with 112 patients aged 65 years or older in Italy (62 patients hospitalised for a hip fracture and 50 outpatients without fracture), 65% of patients living with frailty were at risk of malnutrition and 10% were malnourished as per Mini-

	OR	95% CI for OR		*P*
		Lower	Upper	
MODEL 1				
Age	1.04	0.99	1.08	0.115
Female sex	3.38	1.45	7.87	0.005
Sarcopenia by ASMM	**7.69**	**1.30**	**45.67**	**0.025**
Obesity by fat percentage	1.18	0.45	3.08	0.732
Sarcopenia by ASMM * Obesity by fat percentage	0.64	0.05	7.99	0.732
MODEL 2				
Age	1.03	0.99	1.08	0.145
Female sex	0.60	0.12	3.10	0.546
ASMM	**0.46**	**0.25**	**0.87**	**0.016**
Fat percentage	0.72	0.51	1.02	0.066
ASMM * Fat percentage	1.02	1.00	1.04	0.042

*ASMM Appendicular Skeletal Muscle Mass, OR Odds Ratio, CI Confidence Interval. * denotes interaction term.*

Table 2. Binary logistic regression analysis (dependent variable: non-frail vs. pre-frail or frail; n=118).

	OR	95% CI for OR		*P*
		Lower	Upper	
MODEL 1				
Age	1.02	0.98	1.06	0.370
Female sex	2.01	0.90	4.51	0.091
Sarcopenia by ASMM	3.29	0.59	18.20	0.173
Obesity by fat percentage	0.44	0.18	1.13	0.087
Sarcopenia by ASMM * Obesity by fat percentage	0.55	0.05	6.33	0.631
MODEL 2				
Age	1.02	0.98	1.06	0.407
Female sex	3.68	0.70	19.34	0.124
ASMM	0.78	0.46	1.32	0.348
Fat percentage	0.80	0.57	1.10	0.169
ASMM * Fat percentage	1.01	0.99	1.02	0.386

*ASMM Appendicular Skeletal Muscle Mass, OR Odds Ratio, CI Confidence Interval. * denotes interaction term.*

Table 3. Binary logistic regression analysis (dependent variable: abnormal MNA®-SF; n=111).

Nutritional Assessment (MNA®)[20]. Another cross-sectional study with 133 acutely hospitalised older patients in Austria also examined the association between malnutrition (MNA®) and frailty (SHARE-FI), finding malnutrition or risk of malnutrition in 77% of the total sample and in 47% of robust, in 69% of pre-frail, and in 93% of participants living with frailty[19]. A significant association between SHARE-FI and MNA was also documented by Muszalik et al. in older hospitalised patients in Poland[21]. Our observation that patients living with pre-frailty or frailty had a lower RMR is

also consistent with previous observations[22].

No significant association was observed between SHARE-FI and obesity by fat percentage. In the multivariable analysis adjusting by age and sex, ASMM-confirmed sarcopenia had the strongest OR in association with pre-frailty/frailty, whereas obesity by fat percentage was not independently associated. Analogously, when continuous ASMM and fat percentage measures were used in Model 2, the independent effect of ASMM remained evident. Taken together, results are consistent with the 'cycle of frailty' postulated by Fried et al., in which sarcopenia is a key pathophysiological driver of the FP, but where a primary focus is on weight loss, not obesity[2]. In our study, MNA®-SF was not associated with muscle mass or fat percentage, suggesting better capture of body composition by SHARE-FI than MNA®-SF in our sample.

The main strength of our study is that it evidences an independent association between sarcopenia by BIA and physical frailty as measured by SHARE-FI, and the use of the latter as a surrogate for the original FP is a novel contribution to the literature. Additionally, it highlights that in this sample of falls clinic attendees, the use of SHARE-FI is more appropriate than MNA®-SF when the capture of sarcopenia is the focus. However, our study has several important limitations. Firstly, BIA measurements can be influenced by hydration status[23], and this information was not collected; furthermore, certain prostheses, for which we did not collect information, may potentially affect BIA readings[24], even though a retrospective study by Ukai and Watanabe suggested that metal implants for total hip arthroplasty may not significantly affect them. Secondly, SHARE-FI includes modifications to the original FP items[2] including replacement of the unexplained weight loss criterion by questions on loss of appetite / eating with less frequency, and replacement of slowness (by gait speed) by questions regarding difficulty walking 100 metres / climbing one flight of stairs without resting[13]. Thirdly, as we did not have information on muscle quality, our definition of sarcopenia was only based on ASMM. Fourthly, despite the inclusion in the statistical models of the interaction between sarcopenia and obesity, in our study we lacked robust measures of sarcopenic obesity, and further studies should consider the new SPEN and EASO Consensus Statement for further insights regarding sarcopenic obesity[25]. Furthermore, from this observational study, causality cannot be inferred so it is not possible to extract conclusions regarding pathophysiological mechanisms underlying the association between SHARE-FI and sarcopenia. Finally, as participants were recruited from a falls clinic, they may not be representative of the general population, which limits the external generalisability of our results.

Conclusion

In conclusion, our results support the usefulness of the BIA method employed to evidence the expected relationship between FP (by SHARE-FI) and sarcopenia in falls clinic attendees. An association between abnormal MNA®-SF and sarcopenia was not evident in this sample.

Ethical approval

The study received ethical approval from the Tallaght University Hospital (TUH)/ St. James's Hospital (SJH) Joint Research Ethics Committee (Project ID: 0221; approval date: 4 May 2021). Approval was also granted by St James's Hospital Research & Innovation Office (Reference: 6567, approval date: 26 July 2021). The study adhered to the World Medical Association Declaration of Helsinki on ethical principles for medical research involving human subjects.

Informed consent

All participants provided written informed consent.

Authors' contributions

Elena Lionetti: Conceptualisation, Methodology, Formal analysis, Writing: Original Draft; Eoin Duggan: Methodology, Validation, Investigation, Data Curation, Writing: Review & Editing; Roman Romero-Ortuno: Conceptualisation, Methodology, Validation, Formal analysis, Investigation, Resources, Writing: Review & Editing, Supervision, Project administration, Funding acquisition. All authors approved the final version of the manuscript.

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References

1. Cesari M, Prince M, Thiyagarajan JA, De Carvalho IA, Bernabei R, Chan P, et al. Frailty: An Emerging Public Health Priority. J Am Med Dir Assoc 2016;17(3):188-92.
2. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146-56.
3. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyere O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing 2019;48(4):601.
4. Power L, Mullally D, Gibney ER, Clarke M, Visser M, Volkert D, et al. A review of the validity of malnutrition screening tools used in older adults in community and healthcare settings - A MaNuEL study. Clin Nutr ESPEN 2018;24:1-13.
5. Romero-Ortuno R, Cogan L, Foran T, Kenny RA, Fan CW. Continuous noninvasive orthostatic blood pressure measurements and their

relationship with orthostatic intolerance, falls, and frailty in older people. J Am Geriatr Soc 2011;59(4):655-65.
6. Kojima G. Frailty as a Predictor of Future Falls Among Community-Dwelling Older People: A Systematic Review and Meta-Analysis. J Am Med Dir Assoc 2015;16(12):1027-33.
7. Yeung SSY, Reijnierse EM, Pham VK, Trappenburg MC, Lim WK, Meskers CGM, et al. Sarcopenia and its association with falls and fractures in older adults: A systematic review and meta-analysis. J Cachexia Sarcopenia Muscle 2019;10(3):485-500.
8. Kupisz-Urbanska M, Marcinowska-Suchowierska E. Malnutrition in Older Adults-Effect on Falls and Fractures: A Narrative Review. Nutrients 2022;14(15): 3123.
9. O'Donoghue PJ, Claffey P, Rice C, Byrne L, Cunningham C, Kenny RA, et al. Association between gait speed and the SHARE Frailty Instrument in a Falls and Syncope Clinic. Eur Geriatr Med 2021;12(5):1101-5.
10. Miller MD, Paradis CF, Houck PR, Mazumdar S, Stack JA, Rifai AH, et al. Rating chronic medical illness burden in geropsychiatric practice and research: application of the Cumulative Illness Rating Scale. Psychiatry Res 1992;41(3):237-48.
11. Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. BMC Geriatr 2017;17(1):230.
12. WHO. Falls. Available online: https://www.who.int/news-room/fact-sheets/detail/falls [Accessed 22 October 2023]. 2023.
13. Romero-Ortuno R, Walsh CD, Lawlor BA, Kenny RA. A frailty instrument for primary care: findings from the Survey of Health, Ageing and Retirement in Europe (SHARE). BMC Geriatr 2010;10:57.
14. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging 2009;13(9):782-8.
15. Corporation T. BODY COMPOSITION ANALYZER DC-430MA III Instruction Manual EN 2015 Available from: https://tanita.eu/media/pdf/products-tanita/professional/DC-430/DC-430MA%20Instruction%20Manual%20EN%20%281%29.pdf, Accessed 21 January 2024.
16. Sergi G, De Rui M, Veronese N, Bolzetta F, Berton L, Carraro S, et al. Assessing appendicular skeletal muscle mass with bioelectrical impedance analysis in free-living Caucasian older adults. Clin Nutr 2015;34(4):667-73.
17. Duggan E, Knight SP, Romero-Ortuno R. Relationship between sarcopenia and orthostatic blood pressure recovery in older falls clinic attendees. Eur Geriatr Med 2023;14(3): 439–446.
18. WHO. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser 1995;854:1-452.
19. Dorner TE, Luger E, Tschinderle J, Stein KV, Haider S, Kapan A, et al. Association between nutritional status (MNA(R)-SF) and frailty (SHARE-FI) in acute hospitalised elderly patients. J Nutr Health Aging 2014;18(3):264-9.
20. Valentini A, Federici M, Cianfarani MA, Tarantino U, Bertoli A. Frailty and nutritional status in older people: the Mini Nutritional Assessment as a screening tool for the identification of frail subjects. Clinical Interventions in Aging 2018;Volume 13:1237-44.
21. Muszalik M, Gurtowski M, Doroszkiewicz H, Gobbens RJ, Kedziora-Kornatowska K. Assessment of the relationship between frailty syndrome and the nutritional status of older patients. Clin Interv Aging 2019;14:773-80.
22. Abizanda P, Romero L, Sanchez-Jurado PM, Ruano TF, Rios SS, Sanchez MF. Energetics of Aging and Frailty: The FRADEA Study. J Gerontol A Biol Sci Med Sci 2016;71(6):787-96.
23. Hetherington-Rauth M, Baptista F, Sardinha LB. BIA-assessed cellular hydration and muscle performance in youth, adults, and older adults. Clin Nutr 2020;39(8):2624-30.
24. Yamaguchi CM, Faintuch J, Silva MM, Modolin M, Hayashi SY, Cecconello I. Interference of silicone breast implants on bioimpedance measurement of body fat. Clin Nutr 2012;31(4):574-6.
25. Donini LM, Busetto L, Bischoff SC, Cederholm T, Ballesteros-Pomar MD, Batsis JA, et al. Definition and diagnostic criteria for sarcopenic obesity: ESPEN and EASO consensus statement. Clin Nutr 2022;41(4):990-1000.