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ORIGINAL ARTICLE

A cross-sectional assessment of frailty, falls and perceptions of ageing in people living with HIV using an mHealth platform

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Abstract

Objective: To evaluate frailty, falls and perceptions of ageing among clinically stable individuals with HIV, engaged with remote healthcare delivered via a novel smartphone application.

Methods: This was a multi-centre European cross-sectional, questionnaire-based sub-study of EmERGE participants. Frailty was assessed using the five-item FRAIL scale. Present criteria were summed and categorized as follows: 0, robust; 1–2, pre-frail; 3–5, frail. Falls history and EQ-5D-5L quality of life measure were completed. Participants were asked their felt age and personal satisfaction with ageing.

Results: A total of 1373 participated, with a mean age of 45 (± 9.8) years. Frailty was uncommon at 2%; 12.4% fell in the previous year, 58.8% of these recurrently. Mood symptoms and pain were prevalent, at 43.3% and 31.8%, respectively. Ageing satisfaction was high at 76.4%, with 74.6% feeling younger than their chronological age; the mean felt age was 39.3 years. In multivariable analysis, mood symptoms and pain were positively associated with frailty, falls and ageing dissatisfaction. An increase in pain severity and mood symptoms were respectively associated with 34% and 63% increased odds of pre-frailty/frailty. An increment in pain symptoms was associated with a 71% increase in odds of falling. Pain was associated with ageing poorly, as were mood symptoms, with odds of dissatisfaction increasing by 34% per increment in severity.

Conclusions: Although uncommon, frailty, falls and ageing dissatisfaction were seen in a younger cohort with medically stable HIV infection using a remote care model, promoting screening as advocated by European guidelines.

Members of the EmERGE Consortium are listed in the Appendix.

These were more common in those with pain or mood symptoms, which should be proactively managed in clinical care and explored further in future research.

KEYWORDS
ageing, falls, frailty, HIV, telehealth

INTRODUCTION

Antiretroviral therapy (ART) has transformed HIV into a long-term condition with a positive outlook regarding life expectancy [1]. The simplification of ART regimens, with well tolerated drugs initiated early in diagnosis may reduce the intensity of patient monitoring. Thus, the needs of people living with HIV are changing, driving the development of novel service models that minimize the impact of HIV care on service users' lives, including the use of telemedicine to deliver online, video or telephone consultations and care [2]. These have been championed and accelerated in light of the COVID-19 pandemic due to staff redeployment, service user anxiety, and policies advocating the temporary reduction in face-to-face encounters, with telemedicine promoted as a way of maintaining continuity of care [3, 4].

Service development must be balanced against other emerging issues, such as global cohort ageing [5, 6]. This, coupled with ongoing HIV acquisition in older adults, where diagnoses are often made at a late stage with excess morbidity and mortality, may introduce specific care needs related to ageing that must be reflected in service models [7, 8].

This demographic shift in age has been accompanied by an excess in age-related issues, including falls, multimorbidity and, in particular, frailty [9, 10]. Frailty represents the clinical manifestation of declines in multiple physiological systems, making an individual vulnerable to stressors that trigger deteriorations in health and functional status [11]. As natural ageing is heterogeneous, frailty may help to identify those at greatest risk of negative ageing outcomes. Frailty screening was first advocated for people living with HIV in the 2019 European Clinical AIDS Society guidance [12], and despite an expansion of the guidance in 2021 [13], the optimal method for identifying frailty in this population has yet to be determined.

Therefore, we aimed to investigate frailty, falls and perceptions of ageing in medically stable people living with HIV engaged with remote monitoring of health via a novel smartphone application-based platform within the EmERGE study to ascertain whether there are broader health and/or social/functional needs that may not be addressed via a technology-facilitated HIV service.

METHODS

Study population

A cross-sectional questionnaire-based sub-study was embedded within EmERGE (Evaluating mHealth technology in HIV to improve Empowerment and healthcare utilization: Research and innovation to Generate Evidence for personalized care). EmERGE was a multicentre European study assessing the validity and applicability of an mHealth platform in the self-management of individuals with medically stable, treated HIV infection. The study was conducted across five sites: Antwerp, Belgium; Barcelona, Spain; Brighton, UK; Lisbon, Portugal; and Zagreb, Croatia. All EmERGE participants were eligible, with no pre-specified exclusion criteria. This study, its procedures and, in particular, language around ageing and frailty were reviewed by the EmERGE study PPI group, with service user representation on the steering group.

Collected demographic data, including age, gender identity, ethnicity and HIV parameters, were utilized alongside the EQ-5D-5L [14], a standardized patient-reported outcome measure (PROM) of generic health status comprising a score of today's health rated out of 100 (best health) and five domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each domain has five levels – no, slight, moderate, severe and extreme problems – dichotomized to some versus no problems.

Study procedures

Frailty was defined using the FRAIL scale [15, 16]. It has five criteria, as shown in Figure 1. Criterion scores were summed (potential range 0–5), with 0 defining robust, 1–2 prefrail and ≥ 3 frail. Pre-frailty and frailty were combined to represent tendency towards frailty (not robust), owing to small numbers with frailty.

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Fatigue	'How much of the time during the past 4 weeks did you feel tired?' (All or most of the time scores 1)
Resistance	'By yourself and not using walking aids, do you have any difficulty walking up 10 steps without resting' (Yes scores 1)
Ambulation	'By yourself and not using walking aids, do you have any difficulty walking several hundred metres' (Yes scores 1)
Illness	Presence of 5 or more of the following illnesses scores 1 point: angina, arthritis, asthma, cancer, chronic lung disease, heart failure, diabetes, heart attack, hypertension, kidney disease, stroke
Loss of weight	'without trying, have you lost over 5% of your body weight in the last year?' (Yes scores 1)

FIGURE 1 The FRAIL scale - criteria and scoring [15]

Participants were asked whether they had fallen in the last year for any reason. If yes, they were asked to estimate the number of falls. Participants were divided into those that had fallen and those that had not, and the former into single versus recurrent (more than one) falls.

Perceptions of ageing were gathered using two items from the longitudinal US Health and Retirement Study [17]. The first, 'So far I am satisfied with the way that I am ageing', scored on a Likert scale from strongly disagree to strongly agree. Satisfaction with ageing (somewhat to strongly agree) denoted those ageing well compared with those dissatisfied (ageing poorly). The second asked participants to state the age they feel (felt age). Felt age discrepancy was calculated as chronological age minus felt age, with participants grouped into those feeling younger, older or equal to their current age. Lastly, participants were asked whether issues around ageing with HIV should be included within the mobile phone application.

Statistical analysis

Data were summarized using descriptive statistics in accordance with normal or skewed nature of continuous variables, with categorical variables summarized using frequencies and percentages. Appropriate comparative tests were applied to explore relationships between outcomes (frailty, falls, ageing dissatisfaction) and measured factors (demographic, HIV, functional and PROM data). Common factors of interest were explored in multivariable logistic regression models for each outcome, with age and gender taken as a priori confounders. Strengths of associations were interpreted in line with p-values, with $p \geq 0.1$ representing little or no evidence against the null hypothesis. Analyses were conducted using Stata v.15 (StataCorp, College Station, TX, USA).

Ethics

The study was approved by the Brighton and Sussex Research Ethics Committee (reference 16/LO/2122).

RESULTS

General demographics

In all, 1373/2251 individuals (61%) completed the ageing questionnaire. Participants were 92.6% male and 79.4% white (80.2% white males). Mean age was 45 years [standard deviation (SD) = 9.8], with range 22–75 years; 32.8% were aged > 50. Demographic data are summarized in Table 1, and by site in Table S1.

TABLE 1 Participant demographics across all sites

$N = 1373$	N	%
Participants by site		
Antwerp	224	16.3
Barcelona	384	28.0
Brighton	358	26.1
Lisbon	172	12.5
Zagreb	235	17.1
Gender		
Male	1271	92.6
Female	102	7.4
Ethnicity		
Asian	14	1.0
Black	59	4.3
White	1072	78.1
Hispanic	83	6.0
Other	145	10.6
Age (years)		
Mean (SD)	45 (9.8)	
Age > 50	451	32.8
IDU risk factor	51	3.7

Abbreviation: IDU, Intravenous drug use.

Frailty

Full frailty data were available for 1310/1373 (95.4%) participants: 73.6% were robust (964/1310), 24.4% (320/1310) pre-frail, and 26 (2%) individuals had frailty. Fatigue was the most common FRAIL criterion at 14.3% (190/1333), followed by weight loss in 11.8% (157/1326); 5.8% (77/1330) and 4.9% (66/1333) reported difficulty walking or climbing stairs, respectively. Only three participants (0.2%) had more than four comorbidities, although 26% reported one comorbidity and 9.1% were multi-morbid (two or more comorbidities, excluding HIV).

Falls and functional status

A total of 165/1331 (12.4%) participants reported at least one fall in the last year, with a median of two falls [interquartile range (IQR): 1–3]. Of those falling, 97/165 (58.8%) had fallen recurrently (more than one fall). Regarding functional status based on the EQ-5D-5L, 43.3% (590/1362) reported mood symptoms, 31.8% (434/1361) reported pain, 11.9% (162/1361) reported mobility problems, 11.3% (154/1361) reported problems completing usual day-to-day activities (work, housework, leisure activities) and 3.2% (44/1360) reported problems with self-care (washing and dressing). Self-reported current health was very good, with median score of 85 (IQR: 78–93).

Perceptions of ageing

A total of 1330/1373 (96.9%) participants responded to the statement 'So far I am satisfied with the way that I am ageing', with the majority somewhat or strongly in agreement (895/1330, 67.3%), and 76.4% (1016/1330) agreeing to some degree; these participants were classified as ageing well. Those disagreeing were classified as 'ageing poorly', with 15.8% strongly or somewhat disagreeing with the statement.

The number of participants stating the age they felt was 1298/1373 (94.5%). Overall mean age was 45 (SD = 9.8) and mean felt age was lower at 39.3 (11.1), with a mean of paired differences of −5.7 years; 11.9% felt their age, with most (74.6%) feeling younger (by an average of 8 years; IQR: 4–12) and 13.5% feeling older (by an average of 5 years; IQR: 3–9). A total of 1123/1323 (84.9%) participants agreed to some degree, 41.2% strongly, that issues related to ageing with HIV should be incorporated within the mobile phone application.

Associations with frailty tendency (pre-frail/frail)

There were more women in the pre-frail/frail group (10.1% vs. 6.4%), with no apparent differences in age or current CD4 count, as shown in Table 2. A greater percentage of those with pre-frailty/frailty had multimorbidity (15.9% vs. 6.2%) and falls (22.8% vs. 8.4%). All functional problems were more common in those with pre-frailty/frailty, especially mood symptoms (65.4% vs. 35.7%) and pain (50.0% vs. 25.0% of non-frail individuals); 67.2% of those with pre-frailty/frailty agreed they were ageing well compared with 80.1% if robust. Those with pre-frailty/frailty were more likely to feel older than robust individuals (25.1% vs. 9.1%).

In multivariable analysis, age was associated with lower odds of pre-frailty/frailty, with a 16% decrease seen per 10-year increase [adjusted odds ratio (aOR) = 0.84, 95% CI: 0.72–0.98, $p = 0.024$]. A higher odds of pre-frailty/frailty was observed in those with recurrent falls, mobility problems or difficulty performing usual tasks. Per increment in severity of pain and mood symptoms there were increases in odds of pre-frailty/frailty of 34% and 63%, respectively. Those feeling younger than their actual age had lower odds of pre-frailty/frailty (aOR = 0.61, 95% CI: 0.41–0.93, $p = 0.020$).

TABLE 2 Associations with frailty status, falls and satisfaction with ageing across all participants

		Frailty status		Falls		Satisfaction with ageing	
		Robust ($n = 964$) [*N* (%)]	**Pre-frail/Frail ($n = 346$) [*N* (%)]**	**No fall ($n = 1166$) [*N* (%)]**	**Any fall ($n = 165$) [*N* (%)]**	**Ageing poorly ($n = 314$) [*N* (%)]**	**Ageing well ($n = 1016$) [*N* (%)]**
Age (years)		45 (9.6)	45 (10.5)	44.7 (9.6)	47.1 (11.4)	45.3 (10.1)	44.9 (9.8)
Age > 50		313 (32.5)	115 (33.2)	360 (30.9)	74 (44.8)	105 (33.4)	332 (32.7)
Female		62 (6.4)	35 (10.1)	85 (7.3)	15 (9.1)	13 (4.1)	85 (8.4)
Comorbidity	No comorbidity	663 (68.8)	193 (55.8)	775 (66.8)	85 (51.8)	179 (57.9)	680 (67.2)
	Single	241 (25)	98 (28.3)	296 (25.5)	49 (29.9)	92 (29.8)	251 (24.8)
	Multimorbidity	60 (6.2)	55 (15.9)	89 (7.7)	30 (18.3)	38 (12.3)	81 (8)
Falls		81 (8.4)	79 (22.8)	-	-	58 (18.5)	106 (10.5)
Recurrent falls		34 (43)	58 (77)	-	-	42 (13.5)	55 (5.5)
Frailty	Robust	-	-	881 (76.7)	81 (50.6)	191 (62.8)	769 (76.8)
	Pre-frail	-	-	254 (22.1)	79 (41.3)	98 (32.2)	221 (22.1)
	Frail	-	-	13 (1.1)	13 (8.1)	15 (4.9)	11 (1.1)
Ageing well		769 (80.1)	232 (67.2)	905 (78)	106 (64.6)	-	-
Felt age	Feels younger	749 (79.7)	201 (59.8)	862 (76.3)	101 (62)	192 (62.3)	772 (78.3)
	Feels age	105 (11.2)	50 (14.9)	136 (12)	19 (11.7)	30 (9.7)	125 (12.7)
	Feels older	86 (9.1)	85 (25.3)	132 (11.7)	43 (26.4)	86 (27.9)	89 (9.0)
EQ-5D-5L	General health	90 (80–95)	80 (70–90)	89 (80–95)	75 (65–90)	80 (70–90)	89 (80–94)
	Mobility problems[a]	54 (5.6)	96 (28.2)	102 (8.8)	55 (33.2)	63 (20.3)	93 (9.2)
	Self-care[a]	7 (0.7)	34 (10)	22 (1.9)	21 (12.9)	21 (6.8)	22 (2.2)
	Usual activities[a]	45 (4.7)	101 (29.7)	95 (8.2)	55 (33.5)	63 (20.3)	85 (8.4)
	Pain[a]	238 (24.8)	175 (51.2)	323 (27.9)	101 (61.6)	139 (44.4)	284 (28.2)
	Anxiety/depression[a]	342 (35.7)	223 (65.4)	474 (41)	98 (59.8)	175 (56.1)	397 (39.4)

[a]Any versus no problems.

Associations with falls

Those reporting a fall were older than those without [47.1 (IQR: 44–52) vs. 44.7 (IQR: 39–55 years)], with no differences in gender or ethnicity (all data are shown in Table 2). Individuals with falls were more likely to have comorbidity, especially multimorbidity (18.3% vs. 7.7%), and were more likely to be frail (8.1% vs. 1.1%). They were more likely to report at least some problems with all components of the EQ-5D-5L, with greatest problems related to pain, reported by 61.6% of those with falls compared with 27.9% of those without. Fewer individuals with falls agreed they were ageing well (64.6% vs. 78%), and they were more likely to feel older than their actual chronological age (26.4% vs. 11.7%).

In multivariable analysis, pre-frailty, but not frailty, was associated with increased odds of falling (aOR = 1.70, 95% CI: 1.12–2.57, $p = 0.013$). After adjustment, only pain was associated with falling, with each increment in severity of pain symptoms associated with a 71% increased odds of falling (aOR = 1.71, 95% CI: 1.32–2.21, $p < 0.001$). All data shown in Table 3.

Associations with ageing satisfaction

Individuals' satisfaction with ageing did not vary by age. Women were less likely to feel they were ageing poorly (4.1% vs. 8.4%). Dissatisfaction with ageing was associated with greater comorbidity and multimorbidity (42.1% vs. 10.5%), pre-frailty/frailty (37.1% vs. 23.2%), falls (18.5% vs. 10.5%) and problems in all components of the EQ-5D-5L. Those who felt they were ageing poorly were more likely to feel older than their actual chronological age (27.9% vs. 9.0%) (all data are shown in Table 2). In multivariable analysis, women were less likely to be dissatisfied with how they were ageing (aOR = 0.46, 95% CI: 0.24–0.87, $p = 0.017$). As seen with falls and frailty, pain symptoms (per increment in severity) were associated with ageing poorly (aOR = 1.29, 95% CI: 1.03–1.61,

TABLE 3 Univariable and multivariable analyses exploring factors associated with frail states, falls and dissatisfaction with personal ageing

	Frailty (pre-frail/frail)			Fall			Dissatisfaction with ageing (ageing poorly)		
	Univariable OR (95% CI)	Multivariable aOR[a] (95% CI)	*p*	Univariable OR (95% CI)	Multivariable aOR (95% CI)	*p*	Univariable OR (95% CI)	Multivariable aOR (95% CI)	*p*
Age (per 10 years)	0.97 (0.86–1.10)	0.84 (0.72–0.98)	0.024	1.23 (1.05–1.48)	1.07 (0.88–1.30)	0.473	1.03 (0.91–1.17)	1.08 (0.93–1.25)	0.297
Male	Ref	Ref	-	Ref	Ref	-	Ref	Ref	-
Female	1.64 (1.06–2.53)	1.63 (0.98–2.72)	0.060	1.28 (0.72–2.26)	1.13 (0.59–2.19)	0.713	0.47 (0.26–0.86)	0.46 (0.24–0.87)	0.017
No comorbidity	Ref	Ref	-	Ref	Ref	-	Ref	Ref	-
Single comorbidity	1.40 (1.05–1.86)	1.05 (0.72–1.47)	0.764	1.51 (1.04–2.20)	1.28 (0.85–1.95)	0.238	1.39 (1.04–1.86)	1.19 (0.87–1.64)	0.281
Multimorbidity	3.15 (2.11–4.70)	1.67 (0.99–2.81)	0.053	3.07 (1.92–4.92)	1.58 (0.88–2.80)	0.122	1.78 (1.17–2.71)	0.95 (0.56–1.59)	0.834
Robust	-	-	-	Ref	Ref	-	Ref	Ref	-
Pre-frail	-	-	-	2.83 (1.98–4.03)	1.70 (1.12–2.57)	0.013	1.79 (1.34–2.38)	1.18 (0.84–1.65)	0.346
Frail	-	-	-	10.88 (4.88–24.25)	1.98 (0.69–5.66)	0.203	5.49 (2.48–12.15)	2.00 (0.72–5.53)	0.183
No/single fall	Ref	Ref	-	-	-	-	Ref	Ref	-
Recurrent falls	5.57 (3.57–8.68)	2.40 (1.41–4.08)	0.001	-	-	-	2.70 (1.76–4.12)	1.31 (0.78–2.19)	0.312
Mobility[b]	6.59 (4.59–9.46)	2.19 (1.30–3.68)	0.003	5.21 (3.55–7.64)	1.35 (0.74–2.47)	0.325	2.50 (1.76–3.54)	0.98 (0.57–1.68)	0.945
Self-care[b]	15.14 (6.65–35.51)	1.50 (0.53–4.20)	0.441	7.62 (4.09–14.20)	0.94 (0.39–2.28)	0.893	3.25 (1.76–6.00)	0.78 (0.32–1.89)	0.589
Usual activities[b]	8.57 (5.87–12.53)	2.09 (1.24–3.54)	0.006	5.63 (3.83–8.28)	1.35 (0.74–2.47)	0.334	2.76 (1.93–3.93)	1.05 (0.61–1.81)	0.864
Pain[c]	2.53 (2.13–3.00)	1.34 (1.06–1.69)	0.014	2.52 (2.11–3.03)	1.71 (1.32–2.21)	< 0.001	1.73 (1.48–2.02)	1.29 (1.03–1.61)	0.028
Mood symptoms[c]	2.27 (1.94–2.66)	1.63 (1.36–1.96)	< 0.001	1.76 (1.51–2.14)	1.18 (0.94–1.48)	0.153	2.04 (1.63–2.56)	1.34 (1.12–1.61)	0.001
Feels age	Ref	Ref	-	Ref	Ref	-	Ref	Ref	-
Feels younger	0.56 (0.39–0.82)	0.61 (0.41–0.93)	0.020	0.84 (0.50–1.41)	0.82 (0.47–1.43)	0.486	1.04 (0.67–1.59)	1.07 (0.69–1.68)	0.753
Feels older	2.08 (1.32–3.26)	0.99 (0.58–1.68)	0.960	2.33 (1.29–4.21)	1.10 (0.56–2.16)	0.781	4.03 (2.45–6.62)	2.89 (1.70–4.91)	< 0.001
Satisfied with ageing	Ref	Ref	-	Ref	Ref	-	-	-	-
Dissatisfied	1.96 (1.49–2.58)	1.20 (0.85–1.68)	0.301	1.93 (1.36–2.74)	0.99 (0.65–1.52)	0.968	-	-	-

Abbreviations: CI, confidence interval; aOR, adjusted odds ratio; OR, odds ratio.

[a]Controlled for all variables in the table.

[b]Any versus no problems.

[c]Per increment in severity.

$p = 0.028$), as were mood symptoms, with odds of dissatisfaction increased by 34% per increment in severity (aOR = 1.34, 95% CI: 1.12–1.61, $p = 0.001$).

DISCUSSION

Frailty was uncommon in this cohort at 2% across all sites, lower than other studies, but matching that of people living with HIV with an undetectable viral load in the Veterans Ageing Cohort study (VACS) [18], and similar to European epidemiological data in adults aged 50–65, where prevalence was 3% [19]. Frailty prevalence varies by assessment tool used [20] with both described studies using adaptations of the Fried frailty phenotype (FFP). Although there is no gold standard frailty tool, the FFP is advocated by EACS [12, 13] and is the most commonly used tool in HIV frailty research, where prevalence ranges from 5% to 28% [10]. This is one of the first studies to employ the FRAIL scale to assess frailty in people living with HIV. Its conception draws on the FFP criteria [16], and therefore identifies a more physical, sarcopenia-driven frailty population, excluding psychosocial and cognitive factors that are additional drivers of frailty in people living with HIV [10, 21]. However, it has benefits of easier application, self-evaluation, validation within middle-aged populations, and country-specific adaptation [16, 22, 23]. Additionally, the 2021 EACS guidance promotes the FRAIL scale as a means of identifying frailty in HIV [13].

The lower observed frailty prevalence may reflect a lower mean age than some studies, or relate to the EmERGE study design, which sought to explore the role of an mHealth platform in self-management of people living with HIV rather than ageing. The move from a face-to-face care model may have excluded or appealed less to those with more complex issues, such as those related to ageing, thus creating a 'fitter' study population. This, in part, is evidenced by low levels of comorbidity, which is limited by comorbidities being drawn from the 11 illnesses within the FRAIL scale. Lower numbers of individuals at older ages combined with a potentially fitter self-selecting population may explain the inverse relationship with age and frailty seen in this cohort, which has not been seen in large-scale HIV cohort studies. Alternatively, people living with HIV with frailty and functional impairment may find in-person visits challenging and thus actively seek a remote care option, although this was not the target population for EmERGE. Either way, the risk of adverse outcomes of falls, hospitalization, functional decline and death in those with frailty remain [11], with hospitalization and death greater for those with both HIV and frailty in VACS [18].

Falls represent the most common frailty syndrome and are prevalent in people living with HIV [9, 24]. Here, 12% had fallen in the last year, almost 60% of whom fell recurrently. Recurrent falls may indicate intrinsic and/or extrinsic problems that increase one's risk of falls and should be addressed to reduce falls frequency and minimize fracture risk [25]. Frailty and falls were interlinked with individuals experiencing falls having a two-fold increased odds of frailty, and pre-frailty was associated with falling. In a study of people living with HIV aged ≥ 40 years (mean 51), 18% fell, 39% recurrently, with pre-frailty and frailty independently increasing the odds of recurrent falls [26]. Both frailty and falls were associated with greater multimorbidity, poorer self-reported health status, functional difficulties and poorer regard around personal ageing. It is important to recognize that frailty and falls are occurring in a cohort with lower mean age compared with other studies. Clinically this cohort is, on average, younger than 50 years, which is often taken as the 'older age' cut-off, used by some HIV ageing services [27] and in HIV monitoring guidance [13], meaning that some patients would miss out on screening.

Felt age reflects the age someone feels, which is a subjective representation of an individual's perception of how they are ageing, often viewed in relation to others of their own age [28]. Ageing satisfaction relates to a personal perspective on the ageing process [29]. Encouragingly, the vast majority of participants were satisfied, and felt either younger or equal to their chronological age. This mirrors findings in both the general population and in people living with HIV where age discrepancy in favour of youthfulness occurs early in adult life and persists as chronological age increases [29–31]. Kohli et al. studied felt age in those with and without HIV, finding that, irrespective of serostatus, both groups felt younger than their chronological age, although this was significantly lower in people living with HIV. In those with HIV, feeling younger was associated with greater mental and physical health-related quality of life (HRQoL) [31]. In the Multicentre AIDS Cohort Study, both men with and without HIV reported high levels of ageing satisfaction and lower felt age, with low ageing satisfaction seen in HIV-positive participants with depressive symptoms, diabetes, current smoking or older felt age [29]. These two studies contrast with earlier work by Fumaz et al. where negative ageing perceptions were more common in a group of people living with HIV aged < 50, with 37% feeling older than HIV-negative contemporaries, and 43% perceiving themselves to be ageing prematurely, both of which were more common in women, which is opposite to our findings in which women had lower odds of ageing dissatisfaction [32]. The disparity may be related to the difference in age of these cohorts, as it appears that

ageing perceptions improve with chronological age, which may reflect lived experience, survivorship and resilience, both psychological and physical, in older adults with HIV [31].

Pain was a common association across all of our outcomes of pre-frailty/frailty, falls and dissatisfaction with personal ageing, and mood symptoms for frailty and ageing dissatisfaction, with odds of all outcomes increasing per increment in symptom severity on the EQ-5D-5L. Chronic pain is common in people living with HIV, with one systematic review reporting a prevalence of 54–83% depending on duration of recall [33]. In those with HIV, pain has been associated with negative physical functioning [34], mood symptoms [33, 35, 36], poorer HRQoL [33], falls [37] and frailty [38]. A recent meta-analysis exploring depression in people living with HIV found a global prevalence of 31% (and 22% for Europe), based on a range of depression tools [39]. In the Dutch AGEhiV Study, depressive symptoms were associated with at least a 4.5-fold increased odds of the combined outcome of pre-frailty/frailty, increasing further with greater symptomatology [40]. Depressive symptoms have also been associated with poorer ageing satisfaction in this group [29, 32]. Whether these associations are contributory or consequential regarding the outcomes is unclear, but it is likely that any relationship is bidirectional, which was found to be the case regarding depression and frailty in a large meta-analysis [41]. Pain and mood disorder may serve as barriers to interventions aimed at optimizing physical function and reversing frailty or preventing falls, which in turn may affect perceptions of ageing.

Although uncommon, ageing issues were present, supporting proactive screening for frailty to allow its early identification alongside any precipitants of acute functional decline, prompting management to reverse or reduce these processes. Frailty and falls assessment feature in the 2021 EACS guidance [13]. There is a need to enquire about ageing issues within HIV services and to develop pathways of care to meet these needs. This will inevitably involve an advocacy role to highlight the burden of frailty/frailty syndromes, like falls, within a younger population with unique health and social needs that accompany living with HIV. HIV services could take steps to address issues such as fatigue, pain and symptoms of anxiety and depression which were common in this study and are suggested areas of focus in models of care for those with frailty and/or multimorbidity [42]. Much of this may centre around self-management, which could lend itself well to information provided within a smartphone application.

The concept of the 'fourth 90' advances the UNAIDS 90-90-90 campaign beyond viral suppression, focusing on achieving good HRQoL for all [43]. This is intertwined with ageing with HIV, and our results support the role of exploring and promoting positive attitudes towards ageing, which were not universal among our participants, but where fostered are associated with the adoption of beneficial health behaviours and engagement with health services aimed at prevention [29]. Additionally, irrespective of age, comorbidity, frailty or functional status, there was an appetite for information around HIV and ageing. Interestingly, the desire for such information was lower among those who felt they were not ageing well. This needs to be examined further but could represent individuals with issues that they felt could not be delivered via a mobile platform but needed to be addressed in person, or relate to issues outside of their HIV such as independent physical or psychosocial conditions.

The strengths of the study lie in its large sample size, multi-centre perspective across European countries, as well as its nesting within a larger study not focused on ageing. Ageing research is often limited to those aged over 50, but chronological age does not necessarily predict biological age as ageing trajectories vary [44, 45], with frailty demonstrated across the life span [46]. The FRAIL scale is a validated tool, but this validation does not extend to those under 50, or specifically HIV cohorts. However, we have demonstrated that frailty screening using the FRAIL scale is feasible across large numbers, identifying cases at a prevalence in keeping with other tools. EACS advocate frailty screening, citing use of the FFP or frailty index, and therefore further evaluation of FRAIL scale performance, ideally in comparison with these, would be helpful in ascertaining its broader utility. This could include remote completion in digital format within an app, which is more feasible with FRAIL than with these other tools.

There are limitations, however. The data are cross-sectional and therefore we cannot comment on the causal nature or direction of any of the associations with the outcomes described, and the lack of an HIV-negative control group limits any conclusion regarding the relationship with HIV itself. Results predominantly apply to men, as women are under-represented, with gender demographics reflective of the participating centres rather than the general population, in which frailty is more common in women [11]. This may further explain the lower observed prevalence, and limits our ability to explore the associations with frailty by gender, and indeed ethnicity, due to smaller numbers of non-white participants, further hampered by inconsistent ethnicity recording. Longitudinal data with representative numbers of women and broad ethnicity mix would better describe the ageing trajectories and ageing issues occurring within a well-treated cohort of people living with HIV. Additionally, this was a pragmatic ageing sub-study

utilizing a limited number of screening questions/tools, so it would be beneficial to explore the findings further using more in-depth validated tools, particularly around mood, pain (particularly neuropathic), cognition, functional status and HRQoL. Lastly, there were limited contextual data on each participant, such as socio-economic and behavioural risk factors that have been previously associated with our outcomes of interest, meaning residual confounding is likely.

CONCLUSIONS

Although uncommon, frailty, falls and dissatisfaction with ageing were seen in a younger cohort with medically stable HIV infection using a remote care model. These were more common in those with pain or mood symptoms, which should be proactively managed in clinical care. Information regarding the identification and management of ageing concerns is welcomed by service users and should be retained within any digitally delivered healthcare. However, there remains a lack of consensus around operationalizing optimal frailty screening methods in HIV, be that face-to-face or virtually, which requires ongoing research.

AUTHOR CONTRIBUTIONS

TJL: sub-study lead, study design and analysis, lead author of the manuscript. JHV: study design, contributor to all manuscript drafts. CIJ: study design and analysis, contributor to all manuscript drafts. SB: study design, contributor to all manuscript drafts. AL: site lead, contributor to all manuscript drafts. JB: site lead, contributor to all manuscript drafts. LA: site lead, contributor to all manuscript drafts. MB: site lead, contributor to all manuscript drafts. SZ: site lead, contributor to all manuscript drafts. ET: site lead, contributor to all manuscript drafts. FG: site lead, contributor to all manuscript drafts. JW: EmERGE Chief investigator, sub-study design, contributor to all manuscript drafts.

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CONFLICTS OF INTEREST

No authors report any conflicts of interest in relation to this manuscript.

DATA AVAILABILITY STATEMENT

The data are not publicly available due to the conditions of individual patient consent in this study which started enrolment in 2017. The principal investigators involved in the EmERGE study have full access to all the data of their patients involved in the EmERGE study; datasets will be reusable for further analyses by EmERGE consortium partners only.

ETHICS STATEMENT

EmERGE including the ageing sub-study was approved by the London – Brighton and Sussex Research Ethics Committee, reference 16/LO/2122.

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REFERENCES

1. May MT, Gompels M, Delpech V, et al. Impact on life expectancy of HIV-1 positive individuals of CD4+ cell count and viral load response to antiretroviral therapy: UK cohort study. *AIDS*. 2014;28:1193-1202.
2. Baylis A, Buck D, Anderson J, Jabbal J, Ross S. *The future of HIV services in England shaping the response to changing needs*. Joint United Nations Programme on HIV/AIDS (UNAIDS); 2017.
3. Guaraldi G, Milic J, Martinez E, et al. HIV care models during the COVID-19 era. *Clin Infect Dis*. 2020;19:47. doi:10.1093/cid/ciaa1864
4. Cooper T, Woodward B, Alom S, Harky A. Coronavirus disease 2019 (COVID-19) outcomes in HIV/AIDS patients: a systematic review. *HIV Med*. 2020;21:21-577. doi:10.1111/hiv.12911
5. Unaids. UNAIDS report on the global AIDS epidemic. 2013. http://files.unaids.org/en/media/unaids/contentassets/documents/epidemiology/2013/gr2013/UNAIDS_Global_Report_2013_en.pdf. (Accessed 31 March 2017).
6. Smit M, Brinkman K, Geerlings S, et al. Future challenges for clinical care of an ageing population infected with HIV: a modelling study. *Lancet Infect Dis*. 2015;15:810-818.
7. Tavoschi L, Gomes Dias J, Pharris A, et al. New HIV diagnoses among adults aged 50 years or older in 31 European countries, 2004–15: an analysis of surveillance data. *Lancet HIV*. 2017;4:e514-e521.
8. European Centre for Disease Prevention and Control. *HIV/AIDS surveillance in Europe 2020*. European Centre for Disease Prevention and Control; 2020.
9. Greene M, Covinsky KE, Valcour V, et al. Geriatric syndromes in older HIV-infected adults. *J Acquir Immune Defic Syndr*. 2015;69:161-167.

10. Levett TJ, Cresswell FV, Malik MA, Fisher M, Wright J. Systematic review of prevalence and predictors of frailty in individuals with human immunodeficiency virus. *J Am Geriatr Soc*. 2016;64:1006-1014.
11. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. *Lancet*. 2013;381:752-762.
12. European Clinical AIDS Society. EACS guidelines version 10.0 2019. https://www.eacsociety.org/files/2019_guidelines-10.0_final.pdf.
13. European Clinical AIDS Society. EACS guidelines version 11.0; 2021. https://www.eacsociety.org/guidelines/eacs-guidelines/.
14. Janssen MF, Pickard AS, Golicki D, et al. Measurement properties of the EQ-5D-5L compared to the EQ-5D-3L across eight patient groups: a multi-country study. *Qual Life Res*. 2013;22:22-1727. doi:10.1007/s11136-012-0322-4
15. Abellan van Kan G, Rolland Y, Bergman H, Morley JE, Kritchevsky SB, Vellas B. The I.A.N.A Task Force on frailty assessment of older people in clinical practice. *J Nutr Health Aging*. 2008;12:29-37.
16. Morley JE, Malmstrom TK, Miller DK. A simple frailty questionnaire (FRAIL) predicts outcomes in middle aged African Americans. *J Nutr Health Aging*. 2012;16:601-608.
17. Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JWR, Weir DR. Cohort profile: the health and retirement study (HRS). *Int J Epidemiol*. 2014;43:576-585.
18. Akgün KM, Tate JP, Crothers K, et al. An adapted frailty-related phenotype and the VACS index as predictors of hospitalization and mortality in HIV-infected and uninfected individuals. *J Acquir Immune Defic Syndr*. 2014;67:397-404.
19. Manfredi G, Midão L, Paúl C, Cena C, Duarte M, Costa E. Prevalence of frailty status among the European elderly population: findings from the survey of health, aging and retirement in Europe. *Geriatr Gerontol Int*. 2019;19:723-729.
20. Yeoh H-L, Cheng A, Palmer C, Crowe SM, Hoy JF. Frailty in men living with HIV: a cross-sectional comparison of three frailty instruments. *Antivir Ther*. 2018;23:117-127. doi:10.3851/IMP3185
21. Lorenz DR, Mukerji SS, Misra V, et al. Multimorbidity networks associated with frailty among middle-aged and older people with HIV. *AIDS*. 2021;35:2451-2461.
22. Faller JW, Pereira D d N, de Souza S, Nampo FK, Orlandi F d S, Matumoto S. Instruments for the detection of frailty syndrome in older adults: a systematic review. *PLoS One*. 2019;14:e0216166.
23. Morley JE, Vellas B, van Kan GA, et al. Frailty consensus: a call to action. *J Am Med Dir Assoc*. 2013;14:392-397.
24. Hawkins KL, Brown TT, Margolick JB, Erlandson KM. Geriatric syndromes: new frontiers in HIV and sarcopenia. *AIDS*. 2017;31(Suppl 2):S137-S146.
25. Premaor MO, Compston JE. People living with HIV and fracture risk. *Osteoporos Int*. 2020;31:1633-1644.
26. Tassiopoulos K, Abdo M, Wu K, et al. Frailty is strongly associated with increased risk of recurrent falls among older HIV-infected adults. *AIDS*. 2017;31:2287-2294.
27. Waters L, Patterson B, Scourfield A, et al. A dedicated clinic for HIV-positive individuals over 50 years of age: a multidisciplinary experience. *Int J STD AIDS*. 2012;23:546-552.
28. Westerhof GJ, Wurm S. Longitudinal research on subjective aging, health, and longevity: current evidence and new directions for research. *Annu Rev Gerontol Geriatr*. 2015;35:145-165.
29. Nieves-Lugo K, Ware D, Friedman MR, et al. Self-perception of aging among HIV-positive and HIV-negative participants in the multicenter AIDS cohort study. *AIDS Care*. 2020;32:818-828.
30. Shinan-Altman S, Werner P. Subjective age and its correlates among middle-aged and older adults. *Int J Aging Hum Dev*. 2019;88:3-21.
31. Kohli M, Kamalyan L, Pasipanodya EC, et al. Felt age discrepancy differs by HIV Serostatus: a secondary analysis. *J Assoc Nurses AIDS Care*. 2020;31:587-597.
32. Fumaz CR, Muñoz-Moreno JA, Ferrer MJ, et al. Emotional impact of premature aging symptoms in long-term treated HIV-infected subjects. *J Acquir Immune Defic Syndr*. 2012;59:e5-e8.
33. Parker R, Stein DJ, Jelsma J. Pain in people living with HIV/AIDS: a systematic review. *J Int AIDS Soc*. 2014;17:18719.
34. Merlin JS, Westfall AO, Chamot E, et al. Pain is independently associated with impaired physical function in HIV-infected patients. *Pain Med*. 2013;14:1985-1993.
35. Scott W, Arkuter C, Kioskli K, et al. Psychosocial factors associated with persistent pain in people with HIV: a systematic review with meta-analysis. *Pain*. 2018;159:2461-2476.
36. Uebelacker LA, Weisberg RB, Herman DS, Bailey GL, Pinkston-Camp MM, Stein MD. Chronic pain in HIV-infected patients: relationship to depression, substance use, and mental health and pain treatment. *Pain Med*. 2015;16:1870-1881.
37. Erlandson KM, Allshouse AA, Jankowski CM, et al. Risk factors for falls in HIV-infected persons. *J Acquir Immune Defic Syndr*. 2012;61:484-489.
38. Petit N, Enel P, Ravaux I, et al. Frail and pre-frail phenotype is associated with pain in older HIV-infected patients. *Medicine*. 2018;97:e9852.
39. Rezaei S, Ahmadi S, Rahmati J, et al. Global prevalence of depression in HIV/AIDS: a systematic review and meta-analysis. *BMJ Support Palliat Care*. 2019;9:404-412.
40. Kooij KW, Wit FWNM, Schouten J, et al. HIV infection is independently associated with frailty in middle-aged HIV type 1-infected individuals compared with similar but uninfected controls. *AIDS*. 2016;30:241-250.
41. Soysal P, Veronese N, Thompson T, et al. Relationship between depression and frailty in older adults: a systematic review and meta-analysis. *Ageing Res Rev*. 2017;36:78-87.
42. National Institute of Health and Care Excellence. *Multimorbidity: Clinical Assessment and Management: NICE Guideline [NG56]*. National Institute of Health and Care Excellence; 2016. https://www.nice.org.uk/guidance/ng56
43. Lazarus JV, Safreed-Harmon K, Barton SE, et al. Beyond viral suppression of HIV – the new quality of life frontier. *BMC Med*. 2016;14:94.
44. Mitnitski AB, Graham JE, Mogilner AJ, Rockwood K. Frailty, fitness and late-life mortality in relation to chronological and biological age. *BMC Geriatr*. 2002;2:1-8.
45. Dodds R, Kuh D, Aihie Sayer A, Cooper R. Physical activity levels across adult life and grip strength in early old age: updating findings from a British birth cohort. *Age Ageing*. 2013;42:794-798.
46. Rockwood K, Mitnitski A. Frailty defined by deficit accumulation and geriatric medicine defined by frailty. *Clin Geriatr Med*. 2011;27:17-26.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX: EMERGE CONSORTIUM

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