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Loneliness and physical function impairment: Perceived health status as an effect modifier in community-dwelling older adults in Ghana

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ABSTRACT

Background: Although loneliness and physical function impairment (PFI) are common geriatric syndromes and public health issues, little is known about how their associations vary via self-perception of health. We examine how loneliness is associated with PFI, and whether the association is modified by perceived health status.
Methods: We conducted a cross-sectional analysis of 1201 adults aged ≥ 50 years from the Aging, Health, Psychological Well-being and Health Seeking Behavior Study (AgeHeaPsyWel–HeaSeeB) in Ghana. We assessed loneliness using the three-item short-form of the UCLA Loneliness Scale, and PFI was measured with a seven-item scale on mobility-related deficiencies. Adjusted logistic regressions and moderation analysis evaluated the hypothesized associations.
Results: The prevalence of moderate, severe loneliness, and PFI were 37.5%, 17.7%, and 36.1%, respectively. Regressions showed that loneliness was associated with a 23% increased risk of PFI after adjusting for several potential confounders (OR = 1.23; 95%CI = 1.03–2.81). PFI sub-types revealed similar risks. The loneliness-PFI association was significantly moderated by perceived health status such that a positive health perception attenuated the effect of loneliness on PFI (OR = 0.46, 95%CI = 0.23–0.90).
Conclusions: Individuals who were lonely had significantly higher odds for PFI but the effect was tempered by perceived health status. Social policy and public health practices for healthy aging should address loneliness and negative health perception among older people.

1. Introduction

Feeling extremely lonely is a widespread phenomenon in later life, largely due to a *perceived* lack of close relationships (De Gierveld, 1998). Loneliness is increasingly recognized as an important public health concern for older people and has been salient during COVID-19 (Gyasi et al., 2021a; WHO, 2021). Whilst estimates show that 20–34% of older people in Europe and 25–29% in the US are lonely (Ong et al., 2016; WHO, 2021), some 30–40% of adults aged 60 years and older in sub-Saharan Africa (SSA) report transient and chronic kinds of loneliness (Geller, 2020; Gyasi et al., 2021b). Social relationships, including social integration and subjective social support, are identified as health-protective, whilst social isolation and loneliness are antecedents for morbidity and premature mortality (Gyasi et al., 2021a; Steptoe et al., 2013). The overall health risk of loneliness is comparable to smoking and obesity (Chawla et al., 2021) and has been associated with cardiovascular diseases (Hodgson et al., 2020), mild cognitive impairment (Lara et al., 2019), depression (Ge et al., 2017; Geller, 2020), frailty (Mehrabi & Béland, 2020), and physical impairment (Mushtaq et al., 2014).

Physical function impairment (PFI) characterized by reduced physical activity (PA) and capacity to perform activities of daily living (ADL)

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is a growing challenge in the aging population (Gyasi & Phillips, 2018). PFI propels loss of independence, the onset of disability, and increased mortality risk (del Pozo Cruz et al., 2021), and also defies healthy aging agenda, particularly in SSA where chronic poverty is notable (Gyasi et al., 2021b). Several studies of general population samples indicate that loneliness is a risk factor for PFI with worse outcomes during old age (Jeon, 2020; Kanamori et al., 2014). For example, Philip et al. (2020) found a longitudinal association of loneliness with poorer physical performance among 8,780 participants from the English Longitudinal Study of Ageing (ELSA). Among 3,070 older adults, loneliness strongly predicted increased difficulty in ADL among older Europeans (Shankar et al., 2017). In a 4-year prospective observational analysis from the China Health and Retirement Longitudinal Study, Yu et al. (2020) reported that loneliness increased the risk of grip strength decline among older Chinese women. Previously published literature has hypothesized that loneliness is associated with multiple biologic complications and social deficits, including impaired self-regulation and poor sense of belonging, physical inactivity, inflammation, and neuroendocrine processes that could induce functional impairment (del Pozo Cruz et al., 2021; Loucks et al., 2006). However, the evidence is largely drawn from Western and Asian societies. The association is, thus, unclear in SSA given the heterogeneity and distinctive demographic as well as socio-cultural peculiarities. For example, Christensen et al. (2008) noted that the progression of PFI is diverse and largely depends on the prevailing socio-cultural conditions.

Previous studies have strongly linked perceived health status with incident PFI in old age (Gyasi & Phillips, 2018; Yiengprugsawan et al., 2019). For example, Takahashi et al. (2020) found in a prospective cohort study among older Japanese that poor self-rated health predicted increased functional disability. Using the WHO SAGE datasets, Tetteh et al. (2019) observed 1.6 to 3.7-fold higher odds of functional difficulty in perceiving poor health in Ghana. Crucially, perceived overall positive health status has been underscored to repair or heal emotional and physical or functional ill-health through a psychological milieu (Gyasi & Phillips, 2018). Clinical and public health implications of self-assessment of health, therefore, remain crucial during old age. Despite this knowledge, previous studies have not investigated the potential effect modification by perceived health status in the association of loneliness with PFI. This may preclude robust analysis of the role of loneliness in PFI for a distinct inference. The current study, therefore, examines the association of loneliness with PFI and the modifying effect of perceived health status in this association. We hypothesized that 1) loneliness would positively predict PFI, and 2) self-perception of health would significantly moderate the association of loneliness with PFI.

2. Methods

2.1. Study sample

The data from an AgeHeaPsyWel-HeaSeeB study, a representative survey in Ghana were analyzed (Gyasi, 2018; Gyasi et al., 2021b). A probability-proportional-to-size sampling procedure was employed to sample adults aged $\geq$ 50 years. The study area was demarcated into three sub-regional zones based on geographic and locational uniqueness. Two districts were randomly selected from each zone and the selected districts were delineated into rural and urban neighborhoods using a standardized definition of the Ghana Statistical Services (GSS, 2012) where communities with a population of<5,000 people are considered rural.

We estimated the sample size assuming a 5% margin of error, 95% confidence interval, 1.5 design effect, 5% type 1 and 15% type 2 errors, $p < .05$, and 50% default prevalence of adults aged $\geq$ 50 years (Lwanga & Lemeshow, 1991). The statistical power estimation showed 85% power of the sample size to detect an odds ratio (OR) of $\geq$ 2 and the required minimum sample size was 901. We oversampled by 38% to cater for potential non-responses and to improve generalizability. Thus, 1247 adults were selected using a systematic random sampling approach. However, approximately 3.7% were subsequently excluded based on low effort. Thus, 17(1.4%) were not available during data collection, 11(0.9%) declined to participate, 15(1.2%) missing essential data, and 3(0.2%) contained outliers, leaving the final analytic sample of 1,201 (Fig. 1) In line with the Helsinki Declaration (Carlson et al., 2004), the study protocol was approved by the Committee on Human Research Publication and Ethics, School of Medical Sciences, Kwame Nkrumah University of Science and Technology, and Komfo Anokye Teaching Hospital, Kumasi (Ref: CHRPE/AP/507/16). Study participants were briefed on the research aims and written informed consents were obtained.

3. Measures

3.1. Demographic and health-related variables

Participants self-reported all demographics and health variables; these were selected *a priori* and controlled in regression models (Gyasi & Phillips, 2018). We included *age* (in years), *sex* (women/men), *residence* (rural/urban), marital status (currently married/not married), religion (Christianity/Islam/Traditional religion/others), *education* (primary-level/never, high school-level, more than high school-level), *income* (in Cedis), and employment status (unemployed/ retired/employed). The Global PA Questionnaire assessed PA ($M = 9.03$; $SD = 4.41$) and social networks were assessed based on family and friends contacts and social participation on a continuous scale. *Comorbidity* was assessed with listed chronic conditions based on professional diagnosis by a health care professional ($M = 0.67$; $SD = 0.79$).

3.2. Physical function impairment (PFI)

PFI was assessed with a seven-question scale with high reliability of four groups of mobility-related activities that older persons had difficulty undertaking. These included: 1) intensive tasks (i.e. *vigorous activities* such as weeding, running, lifting heavy objects, and *moderate activities* such as moving a table/chair, washing); 2) upper extremity (i.e. *lifting/carrying groceries*); 3) mobility (i.e. *walking more than one kilometer* and *climbing about several flights of stairs*); and 4) ADL (including *bending/kneeling/stooping*, and *bathing/dressing oneself*) (Ware, 1993; WHO, 2012). Each item was scored on a four-point Likert-style scale: 1 = *not limited at all*, 2 = *less limited*, 3 = *somewhat limited*, 4 = *much limited* with a higher score reflecting a higher PFI. We defined PFI as having difficulty in performing at least one task (PFI > 0). Additionally, each PFI sub-type was dichotomized (no = 0, or yes = 1) for auxiliary analyses. The Cronbach's alpha (α) of PFI in this study was high (α = 0.89).

3.3. Loneliness

A three-item short-form measure of the University of California at Los Angeles Loneliness Scale (UCLA-3) was used to assess loneliness (Hughes et al., 2004; Russell et al., 1997). The questions include: ''How often do you feel you lack companionship?'', ''How often do you feel left out?'', and ''How often do you feel isolated?'' The items were rated on a three-point scale: 1 = *hardly ever/never*, 2 = *some of the time/sometimes*, and 3 = *often/always*. A composite score was calculated for loneliness ranging 3–9 with higher scores reflecting higher levels of loneliness. In this study, the UCLA-3 has a Cronbach's alpha of 0.81 ($M = 5.3$, $SD = 3.9$). The UCLA-3 scale has been validated and shown to be reliable among older adults, and also correlates with the CES-D single-item measure suggesting that both tools measure loneliness construct in a similar way (Hughes et al., 2004). For sensitivity analytical purposes, we constructed dichotomous and three-level loneliness scales. Given that there is no conventional cut-off point for the UCLS-3, we used a cut-off score of 3 to categorize respondents as *not lonely* or *lonely*. The three-level loneliness categorization considered a cut-off points of 0–3 = *not*

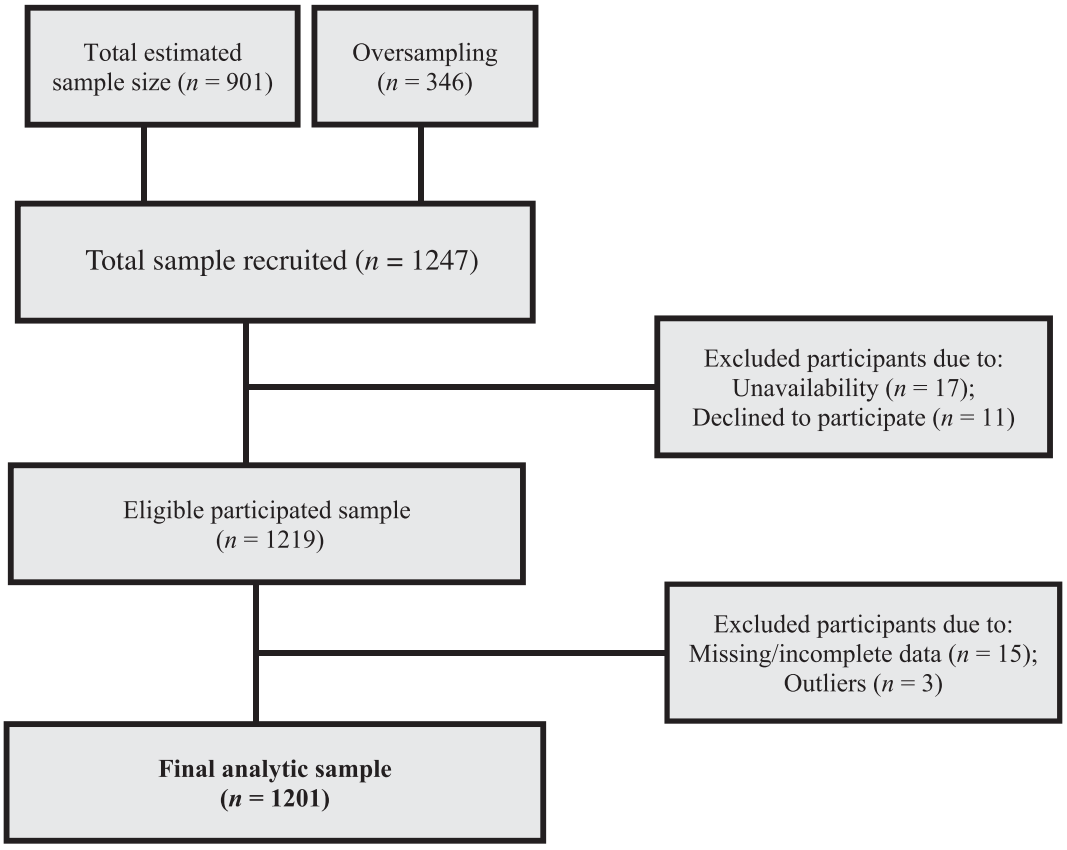

Fig. 1. Flow chart of the selection of study participants.

lonely, 4–6 = *moderately lonely*, and > 6 = *severely lonely*. These cut-off points have been used in previous studies (see for example, Pinto et al., 2021).

3.4. Perceived health status

The effect modifier, perceived health status, was assessed using five subscales of general health in the 36-item short-form survey (SF-36) (Ware, 1993). The items included: 1) ''In general, would you say your health is …?'', 2) ''Compared to two years ago, how would you rate your health in general now?'', 3) ''I am as healthy as anybody I know'', 4) ''My health is better now than two years ago'', and 5) ''My health is excellent now''. For each item, respondents rated their health on a five-point Likert-like scale with 1 = poor perceived health status and 5 = excellent perceived health status. The options for the first question ranged from *poor* to *excellent*. Options for the second item were 1 = *much worse now*, 2 = *somewhat worse now,* 3 = *about the same,* 4 = *somewhat better now,* 5 = *much better now* response options for the last three items were: 1 = *definitely false,* 2 = *mostly false,* 3 = *neither true nor false,* 4 = *mostly true,* 5 = *definitely true*. A composite score was generated by standardizing scores of the five items, calculating the average value. Higher scores indicated better-perceived health status with a strong internal consistency (α = 0.87, *M* = 12.8; SD = 5.6).

3.5. Statistical methods

The SPSS version 25.0 software (IBM SPSS Inc., Chicago, USA) was used for data analysis. The comparisons used the significance level of $p < .05$ for two-sided testing. Univariate descriptive statistics were first calculated to describe the study sample. We summarized the continuous variables as means ± SD and categorical variables as frequencies and percentages. Differences in means of continuous variables and frequency distribution of categorical variables between lonely and not lonely were assessed using independent samples *t*-tests and χ^2 tests of independence respectively.

Logistic regression models, reporting odds ratios (ORs) with 95% confidence intervals (CIs), were used to assess the association between loneliness (exposure) and risk of PFI and its sub-types (outcomes). We fitted three regression models. Model 1 calculated the unadjusted estimates, whilst Model 2 adjusted for all potential confounders. Covariates were selected *a priori* based on their likelihood of association with PFI. Pearson Goodness-of-fit tests were applied to this model. Model 3 added the interaction term, loneliness × perceived health status, to investigate the effect modification in the association between loneliness and PFI by self-perception of health. In cases where the interaction analyses were robust, we evaluated the simple slopes of the association between loneliness and PFI among those who perceived their health as worse (perceived health status = 0), and as better (perceived health status = 1). We conducted a sensitivity analysis to test the associations of loneliness with the overall PFI (PFI > 0) and the PFI sub-types using a three-level category of loneliness. This provided estimates for the effect of loneliness on specific-PFI outcomes. We also considered loneliness as a continuous measure in which PFI outcomes were regressed on the loneliness score.

4. Results

4.1. Descriptive statistics

The sample was about 66 years old and 37% were men. About 45% lived in rural areas, 43% were in marital partnerships, 5% had tertiary-level education and 18% were lonely. Table 1 provides details of the descriptive statistics for all study variables. The analysis explored differences across loneliness groups on all covariates. Age ($t = -2.37$, $p <$

Table 1
Univariate description of study variables and their bivariate associations with loneliness status.

Variable	Mean (SD) or %			Bivariate test
	Overall	Not lonely	Lonely	Statistic and *p*-value
Number	1201	988 (82.3)	213 (17.7)	–
Age	66.15 (11.85)	65.77 (11.86)	67.88 (11.64)	−2.37* [a]
Gender				6.46* [b]
Women	63.3	61.6	70.9	
Men	36.7	38.4	29.1	
Residential status				17.10*** [b]
Rural	45.0	42.2	57.7	
Urban	55.0	57.8	42.3	
Marital status				49.44*** [b]
Married/ partnered relationship	43.4	48.1	21.7	
Not married	56.6	51.9	78.3	
Religious affiliation				15.48*** [b]
Christianity	87.2	88.5	81.2	
Islam	9.2	8.8	11.3	
Traditional religion	1.8	1.2	4.7	
Others	1.7	1.5	2.8	
Level of schooling				9.93** [b]
Primary-level or none	86.2	84.7	92.9	
High school-level	8.7	9.5	4.7	
More than high school-level	5.2	5.8	2.4	
Employment status				64.16*** [b]
Not employed	40.0	34.7	64.3	
Retired	15.7	17.2	8.5	
Employed	44.4	48.1	27.2	
Monthly income	308.18 (338.89)	326.39 (360.57)	213.89 (163.12)	4.00*** [a]
Social network support	6.09 (2.68)	5.94 (4.32)	5.25 (4.47)	2.14* [a]
Physically activity	9.03 (4.41)	8.94 (4.34)	7.84 (4.75)	3.28*** [a]
Perceived health status (PHS)	17.20 (4.20)	16.75 (4.20)	19.10 (3.65)	−7.56*** [a]
Chronic disease count	3.35 (3.95)	3.05 (3.55)	4.6 (5.45)	−5.20*** [a]

[a] Independent samples *T* test
[b] Non-parametric χ^2 test ***$p < .001$; **$p < .005$; *$p < .05$.

.05), female sex ($\chi^2 = 6.46$, $p < .05$), rural living ($\chi^2 = 17.10$, $p < .001$), unmarried ($\chi^2 = 49.44$, $p < .001$), unemployed ($\chi^2 = 64.16$, $p < .001$), negative health perception ($t = -7.56$, $p < .001$) and those having comorbidities ($t = -5.20$, $p < .001$) were more likely to be lonely. Conversely, participants with moderate-to-vigorous PA engagement ($t = 3.28$, $p < .001$), social networks ($t = 2.14$, $p < .05$), and higher-income levels ($t = 4.00$, $p < .001$) were significantly less likely to be lonely (Table 1). The prevalence of PFI and its sub-types were particularly higher among those who were lonely (Fig. 2). For example, the prevalence of PFI was 56% in those who were not lonely but increased significantly to 75% in those with loneliness (χ^2 [1, $N = 1201$] = 64.39, $p < .001$).

4.2. Main regression models

Binary logistic regression results are presented in Table 2. Unadjusted estimations (Model 1) found that loneliness was positively associated with PFI (OR = 2.39, 95%CI: 1.85–3.11). Similar results were observed for all the PFI sub-types (ORs range: 2.19 to 2.61). Adjustment for potential confounders in Model 2 revealed that loneliness increased odds of experiencing PFI by an average of 23% (OR = 1.23; 95%CI: 1.03–2.81). PFI sub-type-specific analysis showed that being lonely was positively associated with difficulty in bending/kneeling (OR = 1.83, 95%CI: 1.27–3.64), bathing/dressing (OR = 2.19, 95%CI: 1.58–3.07), walking (OR = 1.62, 95%CI: 1.14–2.30), lifting/carrying (OR = 1.49, 95%CI: 1.04–2.13), and undertaking moderate activities (OR = 1.57, 95%CI: 1.10–2.22). In Model 3, we included an interaction term, loneliness × perceived health status. The effect modification was significant in relation to PFI > 0 (OR = 0.46, 95%CI: 0.23–0.90), and sub-types, including bending/kneeling (OR = 0.52, 95%CI: 0.29–0.93), walking (OR = 0.63, 95%CI: 0.33–1.89), and vigorous activity (OR = 0.29, 95% CI: 0.15–0.57). Thus, perceived health status modified the positive effect of loneliness on PFI; lonely individuals were less likely to experience PFI if their perceived health status was better.

4.3. Additional models

In sensitivity analyses, we estimated the associations of the three-level loneliness with the PFI sub-type (Table 3). Regressions found that moderately lonely (OR = 1.11, 95%CI: 1.09–2.59), and severely lonely (OR = 1.28, 95%CI: 1.16–2.85) were at a higher risk of PFI than those who were not lonely. Another sensitivity analysis considered loneliness on a continuous scale. Similarly, higher levels of loneliness increased the odds of reporting PFI by an average of 22% (OR = 1.22, 95%CI: 1.10–3.40). Table 3 provides details of loneliness (the continuous measure and three-level loneliness categories) associations with PFI sub-types in fully adjusted models.

5. Discussion

5.1. Main findings

In this representative study of old adults in an innovative SSA context, the prevalence of PFI was more common among individuals who were lonely. Thus, lonely participants were at an increased risk of PFI. This significant association remained robust and evident even after accounting for multiple potential confounders. The risk of PFI increased progressively between moderate and severe loneliness. Moreover, every 1-*SD* increase in loneliness was related to a 22% increased risk of PFI when adjusting for covariates. Finally, a test of potential effect modification revealed a statistically significant difference in the association of loneliness with PFI by perceived health status. To our knowledge, this is the first study to decompose the associations between loneliness, perceived health status, and PFI in later life, particularly in low- and middle-income countries. Our findings re-emphasize that policy and clinical practice may need to recognize the dual burden of social isolation and health outcomes in the remit of successful aging.

5.2. Interpretation of the findings

Research on the functional health impacts of loneliness among older people has received international interest predominantly from Western and Asian countries (Jiang et al., 2020). Our findings resonate with published extant studies showing that loneliness is independently associated with PFI among older adults (Kanamori et al., 2014; Kobayashi and Steptoe, 2018; Yu et al., 2020). For example, using the ELSA dataset, Shankar et al. (2017) found loneliness to be associated with a decreased gait speed and increased ADL disabilities over a 6-year period. A recent UK study involving 8,780 individuals found that loneliness was longitudinally associated with poorer physical performance, after accounting for both time-invariant and time-variant confounders (Philip et al., 2020). Among 3187 older adults aged 61–92 years with type 2 diabetes in the US, McCaffery et al. (2020) identified loneliness as an important correlate of PFI. Finally, a scoping review involving 26 articles found loneliness as the most significant predictor of PFI (Mehrabi & Béland, 2020). Our results uniquely extend previous findings by estimating the effect modification in the loneliness-PFI association by perceived health status, which to our knowledge, has not been explored. Several sensitivity analyses involving the PFI sub-types and the use of

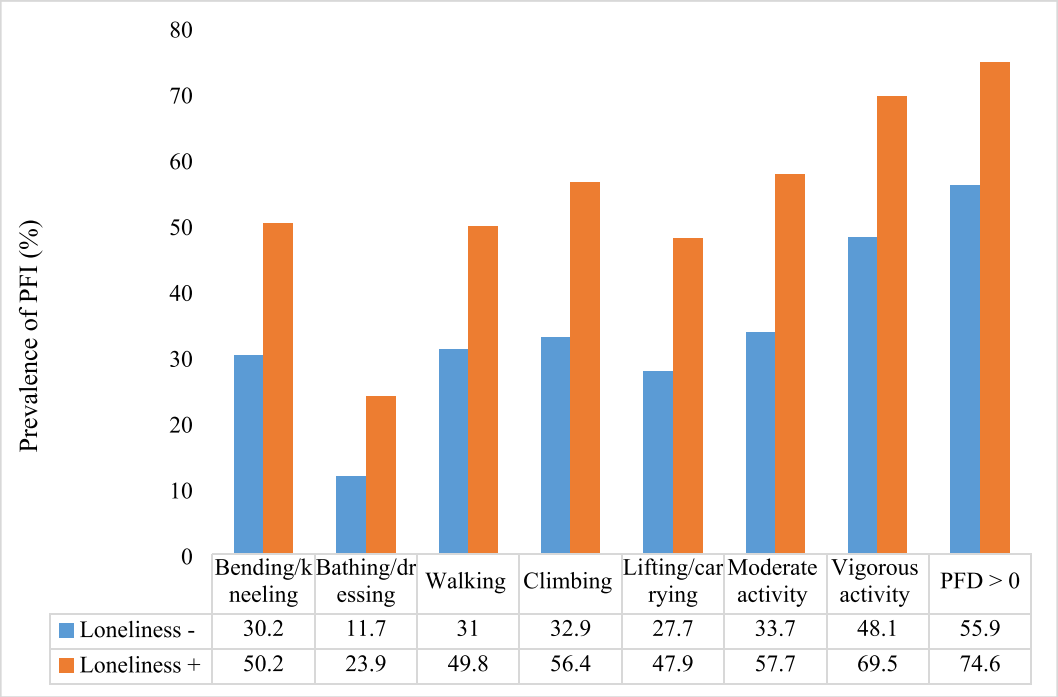

Fig. 2. Prevalence of PFI by loneliness status.

Table 2
Loneliness associations with PFI and interactions with self-rated health: Logistic regression models.

Variables		OR 95% CI Model 1		Model 2 [a]		Model 3 [b]	
Number ADL							
	Bending and kneeling	2.19***	(1.69–2.74)	1.83**	(1.27–3.64)	0.52*	(0.29–0.93)
	Bathing and dressing	2.61***	(2.02–3.37)	2.19***	(1.58–3.07)	0.89	(0.46–1.74)
Mobility							
	Walking	2.24***	(1.77–2.84)	1.62**	(1.14–2.30)	0.63**	(0.33–1.89)
	Climbing	2.33***	(1.82–2.98)	1.20	(0.83–1.74)	0.78	(0.41–1.50)
Upper extremity							
	Lifting and carrying	2.49***	(1.95–3.17)	1.49*	(1.04–2.13)	0.96	(0.50–1.86)
Intensive task							
	Moderate activity	2.54***	(1.99–3.24)	1.57**	(1.10–2.22)	0.66	(035–1.24)
	Vigorous activity	2.46***	(1.88–3.23)	1.30	(0.89–1.92)	0.29***	(0.15–0.57)
PFI > 0		2.39***	(1.85–3.11)	1.23***	(1.03–2.81)	0.46**	(0.23–0.90)

Note: OR = odds ratio; CI = Confidence interval; ADL = activities of daily living; PFI = physical function impairment.

[a] Adjusted for age, sex, residence, marital status, religious affiliation, education level, employment status, income level, social network support, PA, perceived health status, chronic disease count (diabetes, hypertension, cancer, chronic respiratory disease, asthma, stroke, arthritis, depression, chronic Kidney diseases, insomnia and ulcer).

[b] The interaction effect was evaluated between loneliness and self-rated health status (Loneliness × self-rated health) in relation to functional impairment. ***$p < 0.001$; **$p < 0.005$; *$p < 0.05$

various measures of loneliness additionally improved the veracity of findings.

Several mechanisms could plausibly relate loneliness to an increased risk of PFI. First, studies have linked loneliness to various biologic processes such as emotional dysregulation of several psychological responses including affect lability, inflammatory marker concentrations, maladaptive behaviors, and neuroendocrine processes (Cacioppo et al., 2015; del Pozo Cruz et al., 2021; Loucks et al., 2006). These psychiatric and borderline personality syndromes can impel severe functional impairment (Hengartner et al., 2014; Juurlink et al., 2018). Second, loneliness may worsen the underlying health conditions and vulnerabilities via health deteriorating lifestyles or cardiometabolic endpoints which are known risk factors of PFI (Bin Sayeed et al., 2021). Third, previous studies suggest that lonely people perceive social relationship deficits and are less likely to engage and participate socially (Tam-Seto et al., 2016). Thus, lack of social engagements impairs social control and a sense of belonging which may lead to negative lifestyle behaviors. For example, Kobayashi et al. (2018) found that older adults who are socially isolated are less likely to consistently report weekly PA. Poor normative support and synergy to adopt and maintain healthy lifestyle behaviors, including PA, have been identified as antecedents of PFI in old age (Netz et al., 2013).

Fourth, loneliness may disrupt self-regulatory architecture (Lauder et al., 2006). Impaired self-regulation may lead to a reduction in the capacity to seek health care which may worsen the general health status, leading to PFI in old age (McCracken & Phillips, 2017). In addition, loneliness has been related to low levels of autonomy, coping, self-efficacy, self-esteem, and sleep disturbances (Griffin et al., 2020;

Table 3
Adjusted associations between alternative classifications of loneliness and PFI: Multivariable logistic regression models.

	Bending/ kneeling OR (95% CI)	Bathing/ dressing OR (95% CI)	Walking OR (95% CI)	Climbing OR (95% CI)	Lifting/ carrying OR (95% CI)	Moderate activity OR (95% CI)	Vigorous activity OR (95% CI)	PFI > 0 OR (95% CI)
Severity definition of loneliness [a]								
Not lonely	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Moderately lonely	1.659**	2.599***	1.628**	1.470*	1.724**	1.726**	1.395	1.097**
	(1.136–2.423)	(1.839–3.675)	(1.124–2.358)	(1.000–2.160)	(1.170–2.539)	(1.187–2.508)	(0.968–2.010)	(1.086–2.585)
Severely lonely	1.816*	1.235	1.601*	1.854**	0.956	1.157**	1.711*	1.281***
	(1.097–3.007)	(0.763–1.998)	(1.145–2.713)	(1.098–3.129)	(0.559–1.633)	(1.285–2.955)	(1.018–2.875)	(1.162–2.853)
Continuous loneliness score [b]	1.351**	1.150	1.266*	1.367**	1.049	1.146**	1.316**	1.215**
	(1.087–1.680)	(0.941–1.406)	(1.012–1.583)	(1.091–1.713)	(0.834–1.318)	(1.117–3.433)	(1.055–1.641)	(1.103–3.401)

Note: OR = odds ratio; CI = Confidence interval; ADL = activities of daily living; PFI = physical function impairment
Adjusted for age, gender, residence, marital status, religious affiliation, education level, employment status, income level, social network support, PA, perceived health status, chronic disease count (diabetes, hypertension, cancer, chronic respiratory disease, asthma, stroke, arthritis, depression, chronic kidney diseases, insomnia and ulcer).

[a] Loneliness was classified as a 3-level variable, in which those not lonely answered never to all 3 items, those moderately lonely answered some of the time to at least 1 item, and those severely lonely answered often to at least 1 item.

[b] With the loneliness continuous score, respondents were given 1 point for each loneliness item answered "some of the time" and 2 points for each item answered "often." Effect sizes are per unit point increase. ***$p < .001$; **$p < .005$; *$p < .05$.

McLay et al., 2021). These negative affects may, in turn, reduce the capacity to engage in intellectually stimulating activity to protect oneself against PFI (Backe et al., 2018; Lopez, 2017). Finally, biopsychosocial conditions related to loneliness may be important to trigger PFI (Vancampfort et al., 2019). For example, unmarried older adults are likely to practice sedentary behaviors leading to PFI (Tam-Seto et al., 2016). People in employment have also been identified to have stronger social ties, enhanced social functioning, and in turn, provide opportunities to be active (Suetani et al., 2016).

Interestingly, perceived health status modified the association of loneliness with PFI. Moreover, individuals who perceived their overall health outcomes as better were less likely to report PFI in the context of loneliness. This finding possibly indicates that a positive self-perception of health potentially enables a certain extent of functional development and independence (Yiengprugsawan et al., 2019) although the effect could be reciprocal where PFI can, in turn, worsen self-rated health. This finding is in line with previous studies reporting the effect of subjective health on PFI. We previously showed that self-rated health status was a strong predictor of PFI across genders (Gyasi & Phillips, 2018). Lee et al. (2021) found that poor-to-fair self-rated health was strongly associated with ADL limitations. Positive self-assessment of health might retard or delay the mechanisms underlying the loneliness-PFI link, contributing to stimulating functional ability.

5.3. Public health and policy implications

This study holds currency and provides implications for clinical and public health interventions on improving health outcomes in the context of active and healthy aging policies. Our findings, overall, are similar to those reported in population-representative, longitudinal, and experimental studies. It is, therefore, important for clinicians and public health practitioners to understand these health dynamics, and as much as possible, embed emotionally and physically frail older persons in a resourceful positive self-perception of health through interpersonal encouragement and community participation. Our findings suggest the need for strong social networks, particularly among older adults who are functionally challenged (Litwin & Levinson, 2017). In addition, promoting physical health during old age should be prioritized through the creation of enabling and incentive-based environment for regular exercise modules. This may be desirable in retarding the onset of PFI (Gyasi & Phillips, 2018). The promotion of functional health and well-being is important and this approach may include public education programs, clinical therapy, and behavioral change strategies.

6. Limitations

This study has limitations that should be considered when interpreting the results. First, the cross-sectional design of this study did not allow us to establish the direction of associations between loneliness and PFI outcome, which is likely bidirectional. We propose that future studies consider longitudinal data to enable any potential causal inference. Second, we employed self-reported loneliness, perceived health status, and PFI data rather than objectively measured outcomes and thus may be subject to measurement errors. Relying on subjective measures may blur the veracity of the findings due to recall/social desirability bias. Third, although we controlled for potential confounders, residual variables may impact or explain the results.

7. Conclusions

Findings from this representative study show that loneliness is an important risk factor for PFI in later life. Very importantly, our analysis found significant effect modification of the association between loneliness and PFI by perceived health status. Policy interventions and public health efforts to address individual and combined challenges of loneliness and perceived poor health status during old age, including improved interpersonal relations, social participation, and enabling environment for regular PA may well broadly be beneficial to improving functional abilities. Exploring the links of loneliness, and self-rated health, with PFI, longitudinally may enhance understanding of causal mechanisms behind *perceived* relationship deficit and physical health outcomes in older people. Future research should also explore the role of specific aspects of subjective health to improve understanding.

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CRediT authorship contribution statement

Razak M. Gyasi: Conceptualization, Supervision, Methodology, Data curation, Writing – original draft, Writing – review & editing. **Prince Peprah:** Data curation, Writing – original draft, Writing – review & editing. **Kabila Abass:** Writing – original draft, Writing – review & editing. **Lawrencia Pokua Siaw:** Data curation, Writing – review & editing. **Yvonne Dodzi Ami Adjakloe:** Writing – review & editing. **Emmanuel Kofi Garsonu:** Data curation, Writing – review & editing. **David R. Phillips:** Supervision, Data curation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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