

RESEARCH ARTICLE

Perceived fatigability and health-related quality of life among community-dwelling older adults in Nanjing, China

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Abstract

Background: Fatigability is prevalent among older adults and affects quality of life. It has become a public health concern in the current era of rapid population aging. China has the world's largest older population. However, no study has addressed this issue in China.

Objective: This study examined the associations of physical and mental fatigability with physical and mental measures of health-related quality of life (HRQoL), respectively, among community-dwelling older adults in regional China.

Methods: We collected cross-sectional data from residents aged 60 years or older in Nanjing municipality, China, in 2023. We assessed physical and mental fatigability using the 10-item Pittsburgh Fatigability Scale and treated them as categorical variables. We assessed the physical and mental component summaries (physical component summary [PCS] and mental component summary [MCS], respectively) of HRQoL using the SF-12 and treated them as continuous outcome measures. We used mixed-effects linear regression to estimate the mean difference (MD) and 95% confidence interval (CI) in HRQoL PCS and MCS between participants with "less severe" and "more severe" fatigability.

Results: Among the 5,484 participants, the mean values $\pm$ standard deviations of HRQoL PCS and MCS scores were 52.14 ± 8.87 and 36.66 ± 7.09 , respectively. Overall, after full adjustment for potential confounders, higher physical (MD = -1.63 , 95% CI: -2.05 to -1.20) and mental (MD = -1.67 , 95% CI: -2.09 to -1.25) fatigability were both associated with poorer HRQoL PCS. Neither physical nor mental fatigability was associated with HRQoL MCS (physical fatigability: MD = -0.06 , 95% CI: -0.44 to 0.32 ; mental fatigability: MD = 0.29 , 95% CI: -0.09 to 0.67). Moreover, the associations between fatigability and HRQoL among participants stratified by age or sex were broadly similar to those observed among all participants.

Conclusion: This study has public health implications for building a healthy-aging society, suggesting that fatigability may serve as a useful marker for identifying community-dwelling older adults with poorer physical HRQoL in regional China.

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1. Introduction

The world is experiencing rapid population aging, with both the number and proportion of adults aged 60 years or older (hereafter, older adults) increasing.¹ The global number of older adults is projected to increase from 1.0 billion in 2019 to 2.1 billion by 2050.¹ Moreover, such a rapid process of population aging is occurring at an unprecedented pace and will further accelerate in the coming decades worldwide, particularly in developing countries.¹ For China, the largest developing country in the world, 18.7% of the population (approximately 264 million) were aged 60 years or older in 2020, with an increase of 5.44 percentage points from 2010.² Therefore, promoting healthy aging is not only a major challenge but also an important imperative for sustainable development in China and globally.

Older adults tend to experience chronic health conditions and have a lower health-related quality of life (HRQoL).^{3,4} HRQoL, typically defined as an individual's overall perception of their physical health, mental health, and social functioning,⁵ is widely used to assess the impact of diseases and health-related conditions on quality of life.^{6,7} On the other hand, fatigue is one of the most common complaints among older adults, with a prevalence of approximately 50%,^{8,9} and is considered an early indicator of the aging process and health problems.^{10,11} Typically, the term "fatigue" refers to self-perceived lack of energy, a simple and largely subjective concept that does not account for how routine daily activities influence the degree of this perceived lack.^{10,11} Recently, the term "fatigability" has been introduced to assess one's "fatigue" anchored to daily activities of specific intensity and duration.^{11,12} By standardizing perceived lack of energy to activities/tasks, fatigability has emerged as a more sensitive measure of an individual's susceptibility to "fatigue."^{11,13,14} Notably, the Pittsburgh Fatigability Scale (PFS) was developed to measure physical and mental fatigability specifically in older adult populations.^{12,15} The PFS-assessed prevalence of physical and mental fatigability ranged from 41.1% to 56.0% and from 21.8% to 28.9%, respectively, among community-dwelling older adults in the United States of America.¹⁶

In the current era of rapid population aging, investigating the association between fatigability and HRQoL among older adults is of particular interest. However, most existing literature on the fatigability–HRQoL association

has focused on older adults with specific chronic diseases.¹⁷ Therefore, from a public health perspective, it is important to explore the association of fatigability with HRQoL among community-dwelling older residents in addition to those with specific diseases. As the country with the largest older adult population worldwide, China provides a suitable setting for examining the association between fatigability and HRQoL among older adults.²

To better understand the prevalence and associated factors of fatigability among locally representative community-dwelling adults in regional China, a community-based population survey (the Healthy Aging and Healthy Older Residents study on fatigability, HAHOR-fatigability study) was recently conducted in Nanjing, China. The HAHOR study data were analyzed to examine the prevalence and associated factors of fatigability, e.g., physical activity (PA) and sleep.^{18–20} These previous studies showed a high prevalence of fatigability and negative associations between PA or sleep quality and fatigability among older residents in Nanjing, China.^{18–20} On the other hand, HRQoL is a widely used, comprehensive, and important indicator to measure an individual's quality of life, particularly for older adults.^{5–7} Information on HRQoL was also collected from participants in the HAHOR-fatigability study. However, that study did not examine the potential association between fatigability and HRQoL. Moreover, to date, evidence remains limited on the association between fatigability and HRQoL among community-dwelling older adults in China. Therefore, we further analyzed HAHOR data to investigate the association between fatigability and HRQoL among older adults in Nanjing, China.

2. Materials and methods

2.1. Study design and participants

Data analyzed in this study were derived from the HAHOR-fatigability study, which was conducted in Nanjing municipality of China in 2023.^{18–20} In total, Nanjing, a typical mega-city in eastern China, had 12 urban/suburban districts and about 9.3 million registered dwellers in 2020.²¹ Among all the local residents, 20.9% were older adults.²¹ The study design and participants have been detailed elsewhere.^{18–20} Briefly, the inclusion criteria for participants were as follows: (i) were registered community-dwelling adults aged 60 years or older residing in Nanjing, (ii) had no literacy or cognitive/mental problems, (iii) were able to perform daily activities, and (iv) were absence of

acute infectious diseases.^{18–20}

For the HAHOR-fatigability study, the sample size was estimated with consideration of the following factors: (i) nature of a cross-sectional study design, (ii) previously reported prevalence of fatigability (27%) among older adults,²² (iii) multi-stage approach for selecting participants, (iv) 90% statistical power ($1-\beta$) expected, (v) $\alpha = 0.05$, (vi) 90% response rate assumed, and (vii) stratified strategy of data analysis (by sex and age).^{18–20} Therefore, we estimated the sample size to be approximately 6,000 for the HAHOR-fatigability study. This large sample size also supports sufficient statistical power to analyze the fatigability–HRQoL association.

For participant selection, a multi-stage random sampling approach was used to recruit participants from all 12 districts of Nanjing.^{18–20} First, two subdistricts/townships were randomly chosen from each district. Next, one community was selected from each selected street/township, resulting in 24 communities in this study. Therefore, the number of participants ($n = 250$) was assigned to each community by dividing the overall sample size ($n = 6,000$) by the number of participating communities ($n = 24$). Finally, based on the household list, 250 eligible participants were randomly chosen from each selected community with consideration of proportions of older adults by sex (men versus women) and age (60–69 versus 70–79 versus 80+ years) in Nanjing municipality.²¹

Each participant provided written informed consent prior to the study. The Ethics Committee of Nanjing Medical University Affiliated Nanjing Municipal Center for Disease Control and Prevention reviewed and approved the study (PJ2024-A019-01). Data were de-identified before analysis. The study methods followed the recommendations of the Declaration of Helsinki.

2.2. Data collection

The data-collection procedures, instruments, and variable definitions/classifications were based on the “Scheme of the Chinese Chronic Non-Communicable Disease (NCD) and Risk Factor Surveillance,” which was issued by the Chinese National Center for Non-communicable Disease Control and Prevention (CCNCD) to guide epidemiological surveys of common NCDs and associated risk factors in China.²³ At the local community health service center during a scheduled visit, each participant was interviewed to gather self-reported information on sociodemographic characteristics, behavioral and lifestyle factors, common NCDs, fatigability, HRQoL, depressive symptoms, frailty, and sleep quality. We objectively recorded body weight and height to the nearest 0.1 kg and 0.01 m, respectively.

Moreover, we measured each twice and used the mean values to calculate body mass index (BMI, kg/m²).²³ Fasting lipid profiles were also objectively assessed for each participant at certified laboratories using a HITACHI 7180 analyzer (Hitachi Co., Japan) with testing kits from Shanghai Fosun Long March Medical Science Co., China.²³

2.3. Study variables

2.3.1. Outcome variable

Health-related quality of life was the outcome variable and was assessed using the validated Chinese version of SF-12.^{24,25} SF-12 has 12 items categorized into eight domains: general health (GH, one item), physical functioning (PF, two items), mental health (MH, two items), role limitation due to physical health problems (RP, two items), bodily pain (BP, one item), role limitation due to emotional problems (RE, two items), vitality (VT, one item), and social functioning (SF, one item).²⁶ Moreover, the eight domains are typically organized into two subscales—physical component summary (PCS) and mental component summary (MCS). Specifically, PCS, which assesses the physical aspect of quality of life, covers the domains of GH, PF, RP, and BP, while MCS, which measures the mental aspect of quality of life, includes the domains of SF, RE, MH, and VT.²⁶ The standardized algorithm was employed to assign a score to each item, resulting in a total score for each of PCS and MCS ranging from 0 to 100 points, with a higher score indicating higher HRQoL.²⁶

2.3.2. Independent variable

Physical and mental fatigability were treated as independent variables and measured with the validated Chinese version of the Pittsburgh Fatigability Scale (PFS-CHN).^{12,14,27} PFS assessed two dimensions of fatigability—physical and mental.^{12,14,27} Each of physical and mental fatigability was separately measured with an independent 10-item subscale in PFS.^{12,14}

Participants self-reported their perception of tiredness, weariness, and/or exhaustion they would feel after hypothetically completing specifically standardized daily activities,^{12,14} on a scale of 0 to 5, with zero indicating no fatigability (0 points) and five reflecting extreme fatigability (5 points).^{12,14,27} It yielded a total score of 0–50 for each subscale, with higher scores indicating greater perceived fatigability.^{12,14,27} Because no alternative China-specific cutoff values have been established,²⁷ we applied the established original cut-points for fatigability severity for the physical (PFS physical score < 15 = “less severe” fatigability and ≥ 15 = “more severe” fatigability) and mental (PFS mental score < 13 = “less severe” fatigability and ≥ 13 = “more severe” fatigability) subscales.^{12,14,16,28}

2.3.3. Covariates

The analysis adjusted for selected covariates, including participants' sociodemographic characteristics and potential confounding factors of HRQoL. For analytic purposes, the involved sociodemographic characteristics were classified as: age (60–69 [younger-old], 70–79 [middle-old] or 80+ years [oldest-old]), sex (men or women), residence area (urban or suburban), educational attainment (≤ 6 , 7–12 or 13+ years of schooling), marital status (single or married/having a partner), occupation before retirement (domestic worker, service/sales worker, industrial worker, office worker, academic/research staff, or self-employed),^{23,29} and health insurance. Health insurance was classified as Employment Basic Medical Insurance or Resident Basic Medical Insurance according to reported enrollment.^{30,31}

Potential confounders included behaviors and lifestyle, body weight status, and selected chronic conditions. Behavioral and lifestyle factors included drinking, smoking, PA, sedentary behavior (SB), meat intake, vegetable intake, and sleep. All participants were categorized separately as “drinkers” or “non-drinkers” and “smokers” or “non-smokers” according to definitions recommended by CCNCD.²³ We assessed PA in the last seven days using the Chinese version of the International Physical Activity Questionnaire.³² Participants were classified into: “insufficient PA (<150 minutes/week)” or “sufficient PA (≥ 150 minutes/week)” based on the total time of moderate PA and doubled vigorous PA in the past seven days.³³ SB, indicated by screen-viewing time, was categorized as “<2 h/day (shortened SB)” or “ ≥ 2 h/day (prolonged SB).”³³ Weekly frequencies of meat (red plus white meat) and vegetable consumption were collected using a validated Chinese version of the Food Frequency Questionnaire.³⁴ Then, participants were grouped into “reaching recommendation” or “not reaching recommendation” according to weekly intake frequencies of meat and vegetables separately recommended specifically for older adults by the China Nutrition Society.³⁵

Sleep quality in the last month was assessed using the validated Chinese version of Pittsburgh Sleep Quality Index (PSQI-CHN).^{36,37} For the PSQI, sleep quality was assessed across seven domains.^{36–38} The scoring algorithm for PSQI-CHN was adopted strictly from the original PSQI.³⁶ Each PSQI domain was assigned a score of 0–3, resulting in a total score of 0–21 points.^{36–38} For Chinese older adults, a cutoff > 7 , rather than > 5 , has been shown to be more appropriate for identifying participants with poor sleep quality.^{36,37} Therefore, participants were classified as “poor sleep quality (PSQI > 7)” or “good sleep quality (PSQI ≤ 7)” according to this Chinese-sensitive cutoff.^{36,37}

Selected chronic conditions were examined, including hypertension, diabetes, chronic obstructive pulmonary disease (COPD), stroke, coronary heart disease, chronic kidney disease, and cancer. All the information on these chronic diseases was self-reported by participants and recorded as “no” or “yes.”²³ Frailty was assessed with the validated Chinese version of the Groningen Frailty Indicator (GFI), and a cutoff of 3 was used to classify participants as “frail (GFI ≥ 3)” or “not frail (GFI < 3).”³⁹ Using the validated Chinese version of the Patient Health Questionnaire-9 (PHQ-9), participants were identified as having “positive (PHQ-9 score ≥ 5)” or “negative (PHQ-9 score < 5)” depressive symptoms.^{40,41}

Based on BMI cutoffs recommended for Chinese adults, participants were categorized into: “normal weight (BMI < 24.0 kg/m²)”, “overweight (BMI = 24.0–27.9 kg/m²)”, or “obesity (BMI ≥ 28.0 kg/m²).”⁴² Additionally, lipid profile was classified as “normal” for participants if all of the fasting blood triglyceride, cholesterol, high-density and low-density lipoproteins were at normal levels; otherwise, the lipid profile was recorded as “abnormal.”²³

2.4. Statistical analysis

Continuous variables were presented as mean values $\pm$ standard deviation ($M \pm SD$), while categorical variables were presented as counts and percentages (n [%]). One-way ANOVA and Chi-square tests were employed to examine differences in HRQoL and fatigability by sociodemographic characteristics. Next, three mixed-effects linear regression models were fitted to examine mean differences in physical and mental HRQoL scores between participants with “less severe” and “more severe” fatigability, respectively. Model 1 was a univariate analysis with fatigability as the single predictor and community as the random effect. Model 2 was a multivariate analysis with adjustment for age (where applicable), sex (where applicable), residence location, educational attainment, marital status, healthcare insurance, occupation, body weight status, drinking, smoking, PA, SB, consumption of meat and vegetables, selected chronic diseases (diabetes, hypertension, COPD, stroke, coronary heart disease, kidney disease, cancer, and abnormal lipid profile), and those included in Model 1. Model 3 was a fully adjusted analysis that included additional controls for sleep quality, frailty, and depressive symptoms in addition to those included in Model 2. The two-sided significance level was set at $p < 0.05$. Data were analyzed using R (version 4.4.3, R Foundation for Statistical Computing, Austria).

3. Results

We initially randomly selected 6,002 participants, and 5,556 were successfully recruited (response rate = 92.6%).

The reasons 446 participants were not recruited were “refusal” or “unavailable” at the appointed survey dates. Of those, 5,484 participants with complete survey data were included in the analysis. We excluded the 72 participants with incomplete information from the standardized dataset for analysis; therefore, they were unavailable in the present study. Age, sex, and residential area did not differ between participants included in the analysis and those not included. Additionally, the community-level clustering effect was very small, with the intraclass correlation and variance coefficients of 0.06 and 1.3, respectively. Table 1 shows selected participant characteristics by sex. Among the participants analyzed, the mean age $\pm$ SD was 69.7 ± 6.8 ; 57.6%, 31.2%, and 11.2% were younger-, middle-, and oldest-old individuals, respectively. Moreover, 49.0% were men and 39.1% were from urban areas.

Table 2 illustrates the prevalence of physical and mental fatigability among participants. Overall, 59.0% (95% confidence interval [CI]: 57.7 to 60.3) and 51.1% (95% CI: 49.8 to 52.4) of participants had “more severe” perceived physical and mental fatigability, respectively. The proportion of participants with either “more severe” physical or mental fatigability increased with age, reaching the highest among the oldest-old individuals (68.0% and 59.4% for physical and mental fatigability, respectively). Moreover, the proportions of both “more severe” physical (63.6% versus 58.2%) and mental fatigability (55.3% versus 50.4%) were higher among single participants than among those with a spouse/partner. For participants with different educational attainment, the lowest proportions of both “more severe” physical (55.6%) and mental fatigability (48.8%) were observed in those with middle-school education (7–12 years of schooling). Notably, we observed no difference in either “more severe” physical or mental fatigability among participants stratified by sex, residence area, occupation, health insurance, or body weight status.

Table 3 presents the SF-12 physical and mental HRQoL scores for participants. The mean values $\pm$ SD of physical and mental HRQoL scores were 52.14 ± 8.87 and 36.66 ± 7.09 , respectively, among all participants. The oldest-old individuals had the lowest value of physical HRQoL score (46.70 ± 10.30). However, they also had the highest mental HRQoL score (37.82 ± 6.79). Compared to their suburban counterparts, urban older residents self-reported higher physical (52.78 ± 8.25 versus 51.73 ± 9.22) and mental (37.27 ± 7.59 versus 36.27 ± 6.71) HRQoL scores. Across occupations, service/sales persons had the highest physical HRQoL score (53.89 ± 8.38), while domestic workers had the highest mental HRQoL score (36.98 ± 7.04). We also observed differences in physical but not mental HRQoL values by sex, educational level, marital status, or health

insurance. Further, physical and mental HRQoL values did not differ among participants by body weight status.

Table 4 presents associations of physical fatigability with physical and mental HRQoL scores. Overall, after adjustment for sociodemographic characteristics, lifestyle and behaviors, body weight status, and common chronic conditions, “more severe” PFS-assessed physical fatigability was associated with poorer physical (MD = -2.44 , 95% CI: -2.89 to -2.00) but not mental HRQoL score (MD = 0.16 , 95% CI: -0.23 to 0.54). After further adjustment for sleep quality, frailty, and depressive symptoms, the MD was attenuated, but the overall pattern of associations remained unchanged (MD = -1.63 , 95% CI: -2.05 to -1.20 for perceived physical fatigability and physical HRQoL; MD = -0.06 , 95% CI: -0.44 to 0.32 for perceived physical fatigability and mental HRQoL). Notably, when we analyzed data stratified by age or sex, the patterns of association between physical fatigability and physical or mental HRQoL scores were broadly similar to those observed among all participants.

Table 5 presents the associations between perceived mental fatigability and physical and mental HRQoL scores. After controlling for sociodemographic characteristics, lifestyle and behaviors, body weight status, and common chronic conditions, “more severe” PFS-assessed mental fatigability was associated with worse physical HRQoL score (MD = -2.49 , 95% CI: -2.93 to -2.05), whereas it was also significantly associated with mental HRQoL score (MD = 0.49 , 95% CI: 0.12 to 0.87) among overall participants. After further adjustment for sleep quality, frailty, and depressive symptoms, the association between “more severe” PFS-assessed mental fatigability and a poorer physical HRQoL score remained statistically significant (MD = -1.67 ; 95% CI: -2.09 to -1.25). However, the association between “more severe” PFS-assessed mental fatigability and mental HRQoL score was no longer significant (MD = 0.29 , 95% CI: -0.09 to 0.67). Moreover, the association patterns between perceived mental fatigability and physical or mental HRQoL scores were broadly similar across age and sex strata to those observed among all participants.

4. Discussion

This large-scale epidemiological study aimed to investigate associations between perceived physical and mental fatigability and HRQoL among community-dwelling older residents randomly selected from Nanjing municipality, China. Among adults aged 60 years or older analyzed in this study, (i) perceived physical and mental fatigability were highly prevalent; (ii) self-reported physical and mental HRQoL scores measured using the SF-12 were at moderate or lower levels; (iii) “more severe” physical

Table 1. Selected sociodemographic and anthropometric characteristics of participants by sex in Nanjing, China

Sociodemographic and anthropometric characteristics	% (n) of participants			χ^2	p-value ^d
	All	Men	Women		
Overall	5,484	49.0 (2,687)	51.0 (2,797)		
Age (years)				0.20	0.904
60–69	57.6 (3,157)	57.3 (1,540)	57.8 (1,617)		
70–79	31.2 (1,711)	31.5 (846)	30.9 (865)		
80+	11.2 (616)	11.2 (301)	11.3 (315)		
Residence location				0.28	0.599
Urban	39.1 (2,144)	39.4 (1,060)	38.8 (1,084)		
Suburban	60.9 (3,340)	60.6 (1,627)	61.2 (1,713)		
Educational attainment (schooling years)				249.46	<0.001
0–6	49.6 (2,721)	38.8 (1,044)	60.0 (1,677)		
7–12	44.9 (2,465)	53.9 (1,447)	36.4 (1,018)		
13+	5.5 (298)	7.3 (196)	3.6 (102)		
Occupation prior to retirement ^a				83.36	<0.001
Domestic worker	19.6 (1,075)	15.7 (422)	23.3 (653)		
Industrial worker	42.4 (2,327)	42.1 (1,131)	42.8 (1,196)		
Service/sales worker	6.2 (338)	6.2 (165)	6.2 (173)		
Office worker	8.1 (443)	9.8 (264)	6.4 (179)		
Academic/research staff	7.0 (384)	8.6 (232)	5.4 (152)		
Self-employed	16.7 (917)	17.6 (473)	15.9 (444)		
Marital status				42.61	<0.001
Single	13.8 (758)	10.7 (288)	16.8 (470)		
Married/having a partner	86.2 (4,726)	89.3 (2,399)	83.2 (2,327)		
Health insurance ^b				53.23	<0.001
RBMI	56.6 (3,104)	51.6 (1,387)	61.4 (1,717)		
EBMI	43.4 (2,380)	48.4 (1,300)	38.6 (1,080)		
Body weight status ^c				3.93	0.140
BMI < 24	42.8 (2,346)	43.5 (1,169)	42.1 (1,177)		
24 ≤ BMI < 28	41.8 (2,293)	42.1 (1,130)	41.6 (1,163)		
BMI ≥ 28	15.4 (845)	14.4 (388)	16.3 (457)		

Notes: ^aOccupation referred to the job prior to retirement and was classified for each participant based on classifications recommended by the China National Center for Chronic Non-Communicable Disease Prevention and Control. ^bHealth insurance, including Resident Basic Medical Insurance (RBMI) for individuals who do not have a regular job, such as students or disabled individuals, and Employment Basic Medical Insurance (EBMI) for individuals who work in the formal or registered sectors. ^cBody weight status was categorized based on cutoffs of body mass index (BMI) recommendations for Chinese adults. ^dChi-square test.

Table 2. The distribution of fatigability by selected personal sociodemographic and anthropometric characteristics among participants in Nanjing, China

Sociodemographic and anthropometric characteristics	Participants by characteristics (n)	Distribution of participants with “more severe” fatigability by characteristics, % (n)					
		PFS physical score $\geq 15^d$	χ^2	p-value ^e	PFS mental score $\geq 13^d$	χ^2	p-value ^e
Overall	5,484	59.0 (3,233)			51.1 (2,803)		
Age (years)			29.51	<0.001		22.71	<0.001
60–69	3,157	56.5 (1,785)			49.1 (1,549)		
70–79	1,711	60.1 (1,029)			51.9 (888)		
80+	616	68.0 (419)			59.4 (366)		
Sex			2.38	0.123		0.88	0.347
Men	2,687	57.9 (1,556)			50.5 (1,356)		
Women	2,797	60.0 (1,677)			51.7 (1,447)		
Residence location			0.05	0.824		2.61	0.107
Urban	2,144	58.8 (1,260)			52.5 (1,125)		
Suburban	3,340	59.1 (1,973)			50.2 (1,678)		
Educational attainment (years of schooling)			20.73	<0.001		10.84	0.004
0–6	2,721	61.6 (1,675)			52.7 (1,435)		
7–12	2,465	55.6 (1,371)			48.8 (1,202)		
13+	298	62.8 (187)			55.7 (166)		
Occupation prior to retirement ^a			5.78	0.181		6.43	0.266
Domestic worker	1,075	62.3 (670)			54.1 (582)		
Industrial worker	2,327	58.3 (1,357)			51.0 (1,187)		
Service/sales worker	338	60.4 (204)			49.1 (166)		
Office worker	443	58.2 (258)			51.5 (228)		
Academic/research staff	384	57.8 (222)			49.2 (189)		
Self-employed	917	56.9 (522)			49.2 (451)		
Marital status			7.81	0.005		6.11	0.013
Single	758	63.6 (482)			55.3 (419)		
Married/having a partner	4,726	58.2 (2,751)			50.4 (2,384)		
Health insurance ^b			0.38	0.539		0.54	0.461
RBMI	3,104	59.3 (1,841)			50.7 (1,573)		
EBMI	2,380	58.5 (1,392)			51.7 (1,230)		
Body weight status ^c			0.73	0.696		0.00	1.000
BMI < 24	2,346	58.6 (1,374)			51.1 (1,199)		
24 $\leq$ BMI < 28	2,293	58.9 (1,350)			51.1 (1,172)		
BMI ≥ 28	845	60.2 (509)			51.1 (432)		

Notes: ^aOccupation referred to the job before retirement and was classified for each participant based on recommendations by the China National Center for Chronic Non-Communicable Disease Prevention and Control. ^bHealth insurance, including Resident Basic Medical Insurance (RBMI) for individuals who do not have a regular job, such as students or disabled individuals, and Employment Basic Medical Insurance (EBMI) for individuals who work for the formal or registered sectors. ^cBody weight status was categorized based on cutoffs of body mass index (BMI) recommendations for Chinese adults. ^dPhysical and mental fatigability were assessed using the Pittsburgh Fatigability Scale (PFS), with PFS scores ≥ 15 and ≥ 13 indicating “more severe” physical and mental fatigability, respectively. ^eChi-square test.

Table 3. The distribution of HRQoL by selected personal sociodemographic and anthropometric characteristics among participants in Nanjing, China

Sociodemographic and anthropometric characteristics	Participants by characteristics (<i>n</i>)	Distribution of HRQoL by participants' characteristics, mean $\pm$ SD of SF-12 scores ^d					
		Physical score	<i>F</i>	<i>p</i> -value ^e	Mental score	<i>F</i>	<i>p</i> -value ^e
Overall	5,484	52.14 $\pm$ 8.87			36.66 $\pm$ 7.09		
Age (years)			198.69	<0.001		9.95	<0.001
60–69	3,157	53.81 $\pm$ 7.82			36.59 $\pm$ 7.24		
70–79	1,711	51.02 $\pm$ 9.17			36.36 $\pm$ 6.87		
80+	616	46.70 $\pm$ 10.30			37.82 $\pm$ 6.79		
Sex			22.11	<0.001		1.65	0.199
Men	2,687	52.71 $\pm$ 8.62			36.53 $\pm$ 7.16		
Women	2,797	51.59 $\pm$ 9.07			36.78 $\pm$ 7.02		
Residence location			18.27	<0.001		26.49	<0.001
Urban	2,144	52.78 $\pm$ 8.25			37.27 $\pm$ 7.59		
Suburban	3,340	51.73 $\pm$ 9.22			36.27 $\pm$ 6.71		
Educational attainment (years of schooling)			50.12	<0.001		0.06	0.943
0–6	2,721	50.94 $\pm$ 9.50			36.63 $\pm$ 6.97		
7–12	2,465	53.36 $\pm$ 8.02			36.68 $\pm$ 7.21		
13+	298	52.93 $\pm$ 8.15			36.74 $\pm$ 7.19		
Occupation prior to retirement ^a			8.49	<0.001		2.28	<0.05
Domestic worker	1,075	51.18 $\pm$ 8.89			36.98 $\pm$ 7.04		
Industrial worker	2,327	51.78 $\pm$ 9.10			36.85 $\pm$ 7.18		
Service/sales worker	338	53.89 $\pm$ 8.38			36.05 $\pm$ 7.29		
Office worker	443	53.16 $\pm$ 8.07			36.64 $\pm$ 7.56		
Academic/research staff	384	53.00 $\pm$ 8.48			36.33 $\pm$ 6.49		
Self-employed	917	52.67 $\pm$ 8.77			36.18 $\pm$ 6.86		
Marital status			95.95	<0.001		3.01	0.083
Single	758	49.23 $\pm$ 9.84			37.07 $\pm$ 7.06		
Married/having a partner	4,726	52.60 $\pm$ 8.61			36.59 $\pm$ 7.09		
Health insurance ^b			37.26	<0.001		0.004	0.951
RBMI	3,104	51.50 $\pm$ 9.35			36.65 $\pm$ 7.03		
EBMI	2,380	52.97 $\pm$ 8.13			36.67 $\pm$ 7.16		
Body weight status ^c			1.27	0.280		0.74	0.480
BMI < 24	2,346	52.05 $\pm$ 8.98			36.70 $\pm$ 7.18		
24 $\leq$ BMI < 28	2,293	52.34 $\pm$ 8.80			36.54 $\pm$ 6.94		
BMI $\geq$ 28	845	51.82 $\pm$ 8.76			36.87 $\pm$ 7.21		

Notes: ^aOccupation referred to the job before retirement and was classified for each participant based on recommendations by the China National Center for Chronic Non-Communicable Disease Prevention and Control. ^bHealth insurance, including Resident Basic Medical Insurance (RBMI) for individuals who do not have a regular job, such as students or disabled individuals, and Employment Basic Medical Insurance (EBMI) for individuals who work in the formal or registered sectors. ^cBody weight status was categorized based on cutoffs of body mass index (BMI) recommendations for Chinese adults. ^dHealth-related quality of life (HRQoL) was assessed with SF-12, treated as a continuous measure. ^eAnalysis of variance test.

Table 4. The association between perceived physical fatigability and HRQoL among men and women aged 60+ years in Nanjing, China

Category of participants	Physical fatigability ^a	Physical HRQoL score of SF-12 ^b			Mental HRQoL score of SF-12 ^b		
		Mean ± SD % (n/N of participants)	Mean difference (95% CI)		Mean ± SD Model 3 ^f	Mean difference (95% CI)	
			Model 1 ^d	Model 2 ^e		Model 1 ^d	Model 2 ^e
Overall	No	41.0 (2,251/5,484)	Ref.	Ref.	Ref.	Ref.	Ref.
	Yes	59.0 (3,233/5,484)	-2.99 (-3.46 to -2.52)	-2.44 (-2.89 to -2.00)	-1.63 (-2.05 to -1.20)	0.22 (-0.16 to 0.60)	0.16 (-0.23 to 0.54)
Age (years)		N = 5,484					
60–69	No	43.5 (1,372/3,157)	Ref.	Ref.	Ref.	Ref.	Ref.
	Yes	56.5 (1,785/3,157)	-1.74 (-2.29 to -1.20)	-1.75 (-2.28 to -1.21)	-1.15 (-1.67 to -0.64)	-0.12 (-0.63 to 0.39)	-0.17 (-0.67 to 0.34)
70–79	No	39.9 (682/1,711)	Ref.	Ref.	Ref.	Ref.	Ref.
	Yes	60.1 (1,029/1,711)	-3.51 (-4.38 to -2.64)	-2.98 (-3.83 to -2.12)	-1.86 (-2.69 to -1.04)	0.49 (-0.18 to 1.15)	0.33 (-0.34 to 1.00)
80+	No	32.0 (197/616)	Ref.	Ref.	Ref.	Ref.	Ref.
	Yes	68.0 (419/616)	-5.39 (-7.09 to -3.70)	-4.26 (-5.95 to -2.57)	-1.50 (-2.99 to -0.02)	0.92 (-0.24 to 2.06)	0.63 (-0.54 to 1.81)
Sex							
Men	No	42.1 (1,131/2,687)	Ref.	Ref.	Ref.	Ref.	Ref.
	Yes	57.9 (1,556/2,687)	-2.86 (-3.51 to -2.21)	-2.50 (-3.12 to -1.88)	-1.60 (-2.19 to -1.00)	0.17 (-0.38 to 0.72)	0.10 (-0.44 to 0.65)
Women	No	40.0 (1,120/2,797)	Ref.	Ref.	Ref.	Ref.	Ref.
	Yes	60.0 (1,677/2,797)	-3.07 (-3.75 to -2.40)	-2.34 (-2.98 to -1.70)	-1.39 (-2.00 to -0.78)	0.26 (-0.27 to 0.80)	0.17 (-0.36 to 0.71)

Notes: ^aPhysical fatigability was assessed using the Pittsburgh Fatigability Scale (PFS), with PFS ≥ 15 indicating “more severe” physical fatigability. ^bHealth-related quality of life (HRQoL) was assessed with the SF-12, treated as a continuous measure. ^cNo: “less severe” fatigability; Yes: “more severe” fatigability. ^dModel 1 was an unadjusted linear regression analysis with physical fatigability as the single predictor and community as the random effect. ^eModel 2 was a multivariate analysis with adjustment for age (where applicable), sex (where applicable), residence location, educational attainment, marital status, healthcare insurance, occupation, body weight status, drinking, smoking, physical activity, sedentary behavior, consumption of meat and vegetable, selected chronic diseases (diabetes, hypertension, chronic obstructive pulmonary disease, stroke, coronary heart disease, kidney disease, cancer, and abnormal lipid profile), and those included in Model 1. ^fModel 3 was a full-adjustment analysis with further control of sleep quality, frailty, and depressive symptoms in addition to those included in Model 2.

Table 5. The association between perceived mental fatigability and HRQoL among men and women aged 60+ years in Nanjing, China

Category of participants	Mental fatigability ^a	Physical HRQoL score of SF-12 ^b			Mental HRQoL score of SF-12 ^b			
		Mean ± SD % (n/N of participants)	Mean difference (95% CI)		Mean ± SD Model 3 ^f	Mean difference (95% CI)		
	Classification ^c		Model 1 ^d	Model 2 ^e		Model 1 ^d	Model 2 ^e	Model 3 ^f
Overall		N = 5,484						
	No	53.65 ± 8.26 48.9 (2,681/5,484)	Ref.	Ref.	Ref.	36.37 ± 7.42 Ref.	Ref.	Ref.
Age (years)	Yes	50.69 ± 9.19 51.1 (2,803/5,484)	-2.96 (-3.42 to -2.49)	-2.49 (-2.93 to -2.05)	-1.67 (-2.09 to -1.25)	0.56 (0.19 to 0.94)	0.49 (0.12 to 0.87)	0.29 (-0.09 to 0.67)
	No	54.62 ± 7.66 50.9 (1,608/3,157)	Ref.	Ref.	Ref.	36.34 ± 7.44 Ref.	Ref.	Ref.
60–69	Yes	52.96 ± 7.90 49.1 (1,549/3,157)	-1.67 (-2.21 to -1.12)	-1.70 (-2.23 to -1.16)	-1.04 (-1.56 to -0.52)	0.52 (0.01 to 1.02)	0.43 (-0.08 to 0.93)	0.29 (-0.21 to 0.80)
	No	52.77 ± 8.71 48.1 (823/1,711)	Ref.	Ref.	Ref.	36.19 ± 7.36 Ref.	Ref.	Ref.
70–79	Yes	49.39 ± 9.29 51.9 (888/1,711)	-3.38 (-4.24 to -2.53)	-2.94 (-3.38 to -2.11)	-1.80 (-2.60 to -0.99)	0.33 (-0.33 to 0.98)	0.23 (-0.43 to 0.89)	-0.19 (-0.86 to 0.47)
	No	50.26 ± 9.19 40.6 (250/616)	Ref.	Ref.	Ref.	37.16 ± 7.51 Ref.	Ref.	Ref.
80+	Yes	44.26 ± 10.30 59.4 (366/616)	-6.01 (-7.60 to -4.42)	-4.93 (-6.54 to -3.33)	-2.16 (-3.59 to -0.73)	1.12 (0.03 to 2.21)	0.78 (-0.34 to 1.91)	0.26 (-0.90 to 1.42)
	No	54.33 ± 7.86 49.5 (1,331/2,687)	Ref.	Ref.	Ref.	36.19 ± 7.39 Ref.	Ref.	Ref.
Men	Yes	51.12 ± 9.04 50.5 (1,356/2,687)	-3.22 (-3.86 to -2.57)	-2.89 (-3.50 to -2.28)	-1.91 (-2.50 to -1.32)	0.67 (0.13 to 1.22)	0.58 (0.04 to 1.13)	0.42 (-0.13 to 0.97)
	No	52.97 ± 8.58 48.3 (1,350/2,797)	Ref.	Ref.	Ref.	36.55 ± 7.46 Ref.	Ref.	Ref.
Women	Yes	50.29 ± 9.31 51.7 (1,447/2,797)	-2.68 (-3.35 to -2.02)	-2.04 (-2.67 to -1.41)	-1.11 (-1.71 to -0.51)	0.45 (-0.07 to 0.97)	0.37 (-0.15 to 0.90)	0.06 (-0.47 to 0.58)
	No							

Notes: ^aMental fatigability was assessed using the Pittsburgh Fatigability Scale (PFS), with PFS ≥13 indicating “more severe” mental fatigability. ^bHealth-related quality of life (HRQoL) was assessed using the SF-12, treated as a continuous measure. ^cNo: “less severe” fatigability; Yes: “more severe” fatigability. ^dModel 1 was an unadjusted linear regression analysis with mental fatigability as the single predictor and community as the random effect. ^eModel 2 was a multivariate analysis with adjustment for age (where applicable), sex (where applicable), residence location, educational attainment, marital status, healthcare insurance, occupation, body weight status, drinking, smoking, physical activity, sedentary behavior, consumption of meat and vegetable, selected chronic diseases (diabetes, hypertension, chronic obstructive pulmonary disease, stroke, coronary heart disease, kidney disease, cancer, and abnormal lipid profile), and those included in Model 1. ^fModel 3 was a full-adjustment analysis with further control of sleep quality, frailty, and depressive symptoms in addition to those included in Model 2.

and mental fatigability were each associated with poorer physical HRQoL but not mental HRQoL; and (iv) these patterns of association between fatigability and HRQoL were also observed across age and sex subgroups.

Among the overall participants, the mean physical HRQoL score was 52.14, only slightly above 50, whereas the mean mental HRQoL score was 36.66, substantially below 50. This suggests that older residents of Nanjing municipality perceived their HRQoL as low to moderate. This finding was not entirely consistent with those in previous studies of older adults in other regions of China.⁴³⁻⁴⁵ In these studies, participants were also community-dwelling adults aged 60 years or older, and the SF-12 was employed to assess HRQoL.⁴³⁻⁴⁵ However, the PCS and MCS scores were 47.4 and 67.8, respectively, among 174 participants in Hubei province in 2021;⁴³ 43.3 and 50.6, respectively, among 451 subjects in Guangzhou municipality in 2017;⁴⁴ and 50.1 and 47.3, respectively, among 4,350 residents in Shanghai municipality in 2014.⁴⁵ Compared with these three studies, the PCS score in this study was higher than that reported in all three, whereas the MCS score was lower.⁴³⁻⁴⁵ The differences in PCS and MCS scores between the present and previous studies may be attributable to variations in sample size, survey period, and study setting. For example, the Hubei study included only 174 older participants and was conducted during the COVID-19 epidemic,⁴³ whereas the Guangzhou and Shanghai studies were conducted before the COVID-19 epidemic.^{44,45} In contrast, the present study included nearly 5,500 participants and was conducted in Nanjing municipality during the first year following the COVID-19 pandemic.

Clearly, the main findings in this study were twofold: (i) “more severe” PFS-assessed physical and mental fatigability were associated with a lower (i.e., poorer) SF-12 PCS score but not with the MCS score among community-dwelling older adults in regional China; and (ii) the patterns of associations between fatigability and SF-12-based HRQoL remained consistent across strata defined by age and sex. These findings suggest that the observed association between fatigability and HRQoL may be relevant to community-dwelling older adults in Nanjing municipality. Moreover, the findings highlight that perceived fatigability, as measured by the PFS-CHN, may be a useful marker for identifying community-dwelling older adults at risk of poorer physical HRQoL in regional China.

Several mechanisms may underlie the association between fatigability and HRQoL. It has been documented that sociodemographic attributes (e.g., age, sex, educational level), lifestyle and behaviors (e.g., PA, drinking, smoking, unhealthy eating), chronic health conditions (e.g., diabetes,

hypertension), and mental problems (e.g., depression) are associated with worse HRQoL.⁴⁶⁻⁴⁸ Notably, most of these unfavorable factors have also been associated with greater fatigability.⁴⁹⁻⁵² This overlap may partly explain the observed association, as older adults with greater fatigability may be more likely to have adverse health, lifestyle, and psychosocial characteristics that are also associated with poorer HRQoL. In addition, fatigability may reflect age-related physiological and biological changes and declines in functional capacity, which could adversely affect HRQoL.¹⁰ Moreover, PFS-assessed fatigability has been shown to be a strong predictor of mortality, and mortality itself is associated with HRQoL.^{28,53} Collectively, these findings provide several plausible pathways linking greater fatigability with poorer HRQoL, although the mechanisms underlying this association warrant further investigation.

Conceptually, physical and mental HRQoL represent distinct aspects of perceived quality of life and are assessed using separate component scores.⁵ Specifically, in the SF-12-based HRQoL, the physical dimension includes general health, physical functioning, role limitations due to physical health problems, and bodily pain, while the mental dimension encompasses mental health, role limitations due to emotional problems, vitality, and social functioning.²⁶ The non-significant association between fatigability and the mental dimension of HRQoL in the present study may, at least partly, be explained by several factors. First, the risk factors associated with physical and mental HRQoL are not entirely overlapping because these dimensions capture different aspects of health and functioning.³ For example, physical HRQoL may be more strongly affected by medication-related chronic health conditions, particularly multimorbidities, whereas mental HRQoL may be more strongly influenced by emotional problems (e.g., loneliness, depression).³ Second, among older adults, fatigability may serve as an early indicator of unfavorable physical health and declining functional capacity and, therefore, may be more directly related to the physical dimension of HRQoL.^{10,16,54} Third, previous evidence suggests that fatigability may affect physical functioning more than mental health and may explain a larger proportion of the variance in physical than in mental HRQoL.⁵⁵ Fourth, PFS-assessed fatigability reflects an individual's perceived ability to perform standardized daily activities.^{12,14} Although it is self-reported, the assessment is anchored to predefined activities and their associated intensity or duration. In contrast, the mental component of the SF-12 primarily captures subjective perceptions of emotional and social functioning.¹⁶ Thus, the constructs assessed by PFS-based fatigability and mental HRQoL may have relatively limited conceptual overlap, which could partly explain the non-significant association between

fatigability and mental HRQoL. Finally, differences in the psychometric performance of the PCS and MCS in the present sample may also have contributed to the findings. The Cronbach's α coefficients for the SF-based PCS and MCS were 0.85 and 0.69, respectively, while the corresponding Spearman–Brown split-half reliability coefficients were 0.89 and 0.52. This suggests that PCS showed better internal consistency and split-half reliability than the MCS in capturing HRQoL among the study participants. The MCS's relatively lower reliability may have reduced its ability to detect an association with fatigability and may also have contributed to the comparatively low MCS scores observed in this study. Nevertheless, this explanation remains speculative, as the MCS's psychometric performance does not necessarily account for the underlying relationship between fatigability and mental HRQoL. Importantly, none of these potential explanations, individually or collectively, can definitively explain why fatigability was associated with physical but not mental HRQoL in the present study. Rather, they represent plausible interpretations of the observed findings. Further well-designed longitudinal and mechanistic studies are therefore needed to clarify the pathways linking fatigability with the physical and mental dimensions of HRQoL among older adults.

Notably, we estimated the sample size primarily based on the previously reported fatigue prevalence of 27% among community-dwelling older adults in the United States of America^{16,22} because comparable prevalence estimates were unavailable from China. However, the actual prevalence of physical or mental fatigability exceeded 50% among all participants in the present study. Therefore, the prevalence observed in our sample was substantially higher than assumed during sample-size estimation, resulting in more participants with fatigability than anticipated. This may have provided greater statistical power for stratified analyses by age and sex, although power also depends on subgroup sizes and the magnitude of the associations examined.

As the first exploratory study to investigate the association between fatigability and SF-12-based HRQoL among community-dwelling older adults at the regional level in China, the present findings have important implications for building healthy-aging societies. The world is experiencing rapid population aging, with both the number and proportion of people aged 60 years and older increasing steadily.¹ Globally, the number of older adults is projected to double between 2019 and 2050.¹ China is of particular importance in this context, as it had the largest older population in the world in 2020.² Consequently, promoting healthy aging and enabling older adults to live longer while maintaining satisfactory HRQoL represents

a major public health challenge worldwide, particularly in rapidly aging countries such as China. The present findings highlight the potential public health relevance of fatigability as a marker of poorer HRQoL among older adults in regional China. In particular, assessing fatigability may help identify community-dwelling older adults who are more likely to experience poorer physical HRQoL and who may benefit from further assessment or preventive interventions.

This study has several strengths. First, more than 5,000 community-dwelling older adults were randomly selected from across Nanjing municipality, potentially enhancing the representativeness of the study population relative to approximately 1.95 million local older residents in the municipality.¹⁷ Second, we assessed HRQoL using the validated Chinese version of the SF-12, facilitating comparison with other studies that have used the SF-12 to assess HRQoL in China. Third, we assessed fatigability using the validated Chinese version of the PFS, a well-established instrument for measuring perceived fatigability. Fourth, the analyses adjusted for a broad range of potential confounders, including sociodemographic and anthropometric characteristics, lifestyle and behavioral factors, and chronic health conditions. Finally, the study identified a meaningful pattern of findings: both physical and mental fatigability were negatively associated with physical, but not mental, HRQoL among community-dwelling older adults in regional China.

Several limitations should also be acknowledged: (i) the cross-sectional design precludes conclusions regarding causality or temporal direction. Although greater fatigability was associated with poorer physical HRQoL, the reverse pathway is also plausible, whereby poorer physical HRQoL may contribute to greater perceived fatigability. Thus, the observed relationships should be interpreted as cross-sectional associations rather than causal effects; (ii) both fatigability and HRQoL were assessed using self-reported, albeit validated, instruments. Self-reported measures may be influenced by subjective perception, reporting tendencies, and recall. In addition, some SF-12 components may overlap conceptually with aspects of fatigability, potentially influencing the observed associations and complicating their interpretation; (iii) information on lifestyle and behavioral factors and chronic diseases was self-reported, introducing the possibility of recall or reporting bias; (iv) although age and sex distributions were considered when selecting participants within communities, the sampling approach may not have ensured equal selection probabilities for all eligible older adults. Therefore, selection bias cannot be completely excluded; (v) individuals with difficulties understanding

written materials, cognitive or psychological problems, inability to perform daily activities, or acute infectious diseases were excluded. Consequently, the study population may not fully represent the broader population of community-dwelling older adults in Nanjing, China, particularly those with greater functional or health-related limitations; (vi) the associations between fatigability and HRQoL observed in this study were based on participants randomly selected from Nanjing municipality, a developed region in China. Therefore, the external validity of the findings may be limited in other settings, including rural areas, western regions, and lower socioeconomic populations in China. Moreover, because HRQoL is culturally and linguistically sensitive, direct comparisons with findings from other countries should be made cautiously. The generalizability of the present findings may therefore be primarily applicable to the Chinese context; (vii) this study was designed as a pilot and exploratory investigation of the association between fatigability and SF-based HRQoL among community-dwelling older adults at the regional level in China. As relatively few previous studies have examined this specific association, opportunities for direct comparison with existing evidence were limited. The exploratory nature of the study should therefore be considered when interpreting the findings and highlights the need for confirmation in independent populations; (viii) the goodness-of-fit indicated that the marginal and conditional R^2 values were both 0.24 for the fully adjusted models examining the association between fatigability and PCS, and 0.03 for the association between fatigability and MCS. These results indicate that the fully adjusted models accounted for substantially more variation in PCS than in MCS. However, R^2 reflects the explanatory performance of the entire model and should not be interpreted as indicating that fatigability alone accounted for the observed variation in physical or mental HRQoL; (ix) physical and mental fatigability were dichotomized in the analyses. Although this approach facilitated interpretation and stratified comparisons, dichotomizing continuous or ordinal PFS scores may result in information loss and may not capture all aspects of fatigability in analysis; (x) the variance inflation factor (VIF) analyses suggested limited multicollinearity among the lifestyle/behavior and chronic conditions included as covariates. The lowest and highest VIFs were 1.02 (vegetable intake) and 1.51 (smoking), respectively. Moreover, the VIFs for selected chronic conditions ranged from 1.05 (COPD) to 1.14 (hypertension). The VIF for the combination of physical and mental fatigability was 2.85, indicating some correlation between these two predictors but not substantial multicollinearity by commonly used thresholds. Nevertheless, because some degree of correlation may

exist among covariates and between the two fatigability measures, the possibility of over-adjustment cannot be entirely ruled out; (xi) the mean difference in physical HRQoL between participants with “less severe” and “more severe” physical or mental fatigability was approximately 1.6 points. This represents a cross-sectional population-level difference in physical HRQoL and should not be interpreted as evidence of clinical or practical significance. In particular, statistical association does not necessarily imply that the magnitude of the observed difference is clinically meaningful. Overall, these limitations suggest caution in interpreting the findings.

Future research should include longitudinal studies, preferably intervention studies, to clarify the temporal and potentially causal relationships between fatigability and HRQoL among community-dwelling older adults. Moreover, digital biomarkers, such as accelerometry-based measures of performance fatigability, could complement self-reported measures by providing more objective assessments of what individuals can actually do.⁵⁶ Additionally, cross-cultural and cross-regional studies are also warranted to examine the external validity and generalizability of the association between fatigability and HRQoL across different populations and settings. Importantly, intervention studies should further determine whether changes in fatigability are accompanied by meaningful improvements in HRQoL and whether the magnitude of differences in HRQoL has clinical and/or public health relevance.

5. Conclusion

In conclusion, greater physical and mental fatigability were associated with poorer physical, but not mental, SF-12 HRQoL among community-dwelling older adults aged 60 years and older in Nanjing municipality, China. However, given the cross-sectional study design, sampling approach, potential selection bias, and reliance on self-reported measures, these findings should be interpreted cautiously and should not be taken to imply a causal relationship. Nevertheless, in the context of rapidly aging global populations, the findings have potential public health relevance for promoting healthy aging. The findings suggest that fatigability may be a useful marker for identifying community-dwelling older adults with poorer physical HRQoL in regional China.

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Conflict of interest

The authors declare no competing interests.

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Ethics approval and consent to participate

Written informed consent was obtained from each participant before the study, which was approved by the Ethics Committee of Nanjing Medical University Affiliated Nanjing Municipal Center for Disease Control and Prevention (PJ2024-A019-01).

Consent for publication

Not applicable.

Availability of data

Data are available upon request to the corresponding authors.

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