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Association of early and late onset of chronic diseases with physical frailty among older Indian adults: study based on a population survey

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Abstract

Background There is a limited understanding of the age at onset of chronic diseases linked to an increased risk of physical frailty among older persons, despite the well-established link between chronic diseases and frailty. This study aimed to examine the prevalence of early- and late-onset chronic diseases and their association with physical frailty and its components in older adults in India.

Methods Data from the Longitudinal Aging Study in India (LASI), wave 1 (2017–2018), were used with a sample of 31,386 older adults aged 60 years and above, including 15,043 males and 16,343 females. Physical frailty was assessed by using an adapted version of the frailty phenotype developed by Fried et al.. The main explanatory variable was self-reported age at the onset of chronic diseases, and a cutoff of 50 years was considered to define the early and late onset of chronic disease. Multivariable logistic regression models were used to examine the association between early and late onset of chronic diseases and physical frailty and its components.

Results Overall, 30.65% of the sample population was physically frail, and frailty was much higher in the 80 years and aboveage group (54.23%). Compared to individuals without any morbidity, those with late onset of single morbidity (AOR: 1.22, CI: 1.09–1.36) and multimorbidity (AOR: 1.49, CI: 1.29–1.71) had higher odds of physical frailty. Similarly, multimorbidity was significantly associated with most components of physical frailty, with the exception of weight loss. Older adults with late-onset hypertension (AOR: 1.22, CI: 1.09–1.36), stroke (AOR: 1.75, CI: 1.35–2.27), and heart disease (AOR: 1.58, CI: 1.21–2.06) had higher odds of physical frailty than those without any morbidity. The odds of being physically frail were higher in those with early onset arthritis (AOR: 1.55, CI: 1.15–2.08) and late-onset of arthritis (AOR: 1.35, CI: 1.13–1.61) than in those without any morbidity. Additionally, the odds of physical frailty were higher among those with late-onset chronic diseases, particularly heart disease (AOR: 3.39, CI: 1.31–8.77) and psychiatric disease (AOR: 3.00, CI: 1.19–7.61), compared to individuals with early onset of these conditions.

Conclusions This study found significant positive associations between early and late onset chronic diseases and physical frailty and its components among older Indians. These findings underscore the importance of managing

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late-onset chronic diseases, especially heart diseases and psychiatric conditions, to mitigate frailty in older adults. These findings also emphasize the critical role of age at onset of specific chronic conditions and multimorbidity in the development of frailty, suggesting that targeted disease-specific interventions could help delay or prevent frailty.

Keywords Chronic disease, Multimorbidity, Physical frailty, Older adults

Background

One of the challenging aspects of population ageing is the increasing prevalence of frailty. Physical frailty is strongly linked to adverse outcomes including disability, falls, fractures, long-term care, dependency, and mortality [1–3]. However, physical frailty can be reversible because physical and dietary interventions can improve a person's physical condition [4, 5].

The onset and progression of frailty can be influenced by the natural course of chronic diseases, with some chronic diseases manifesting at younger ages [6] and the majority emerging in middle-aged and older populations [7]. In addition, multimorbidity increases the chance of physical frailty over time in a steeply escalating fashion, depending on the number of chronic diseases present [8]. In various studies, diabetes, cardiovascular disease, and pulmonary disorders have been strongly associated with physical frailty, suggesting causal relationships among these diseases [9–12]. However, compared to having a single disease, having two or more conditions increases the likelihood of physical frailty [13]. According to a meta-analysis, physical frailty is relatively widespread in individuals with ischemic heart disease, affecting approximately one-fifth of these individuals [14]. Vascular dysfunction and related pathological changes have been shown to be the underlying mechanisms of physical frailty [15]. Similarly, chronic kidney disease is associated with physical frailty, with this relationship being mediated by various vascular and non-vascular diseases [9].

Physical frailty is highly prevalent among older adults with cardiovascular illnesses and is associated with adverse health outcomes, including an increased risk of mortality [16, 17]. Evidence also suggests a strong link between cardiovascular conditions such as atrial fibrillation, hypertension, and heart failure, and the development of physical frailty [18]. A recent systematic review in the US indicated that 14% of people with hypertension also had physical frailty, whereas over 70% of physically frail individuals had hypertension [3]. A similar finding was observed among individuals with heart failure, where physical frailty accounted for nearly half of all patients with heart failure [19]. Furthermore, physical frailty is frequent in both early and advanced rheumatoid arthritis and is associated with hospitalization and mortality. It is suggested that physical frailty in rheumatoid arthritis is dynamic and, for some, may be reduced by controlling disease activity in the early stages of the disease [20].

A previous study found that early- and late-onset of certain conditions, including hypertension, stroke, and arthritis, as well as late-onset multimorbidity, were associated with poor mental, physical, and functional health in older Indians [21]. Another study found that early or combined early and late multimorbidity increases the likelihood of physical disabilities, social limitations, higher frailty, and poorer physical and mental health [22]. However, there is a limited understanding of the age at onset of chronic diseases linked to an increased risk of frailty among older persons, despite the well-established link between chronic diseases and frailty. Exploring the associations between early- and late-onset chronic diseases and frailty could aid in identifying vulnerable subpopulations and in preventing frailty and/or delaying its progression. Therefore, we aimed to examine the associations between physical frailty and early- and late-onset chronic diseases, such as hypertension, diabetes, heart attack, heart disease, stroke, cancer, lung disease, arthritis, osteoporosis, and psychiatric diseases, among older adults in India.

Methods

Data

The Longitudinal Ageing Study in India (LASI) Wave 1 (2017–2018) data were used. The survey collected data on the health, economic, and social factors and consequences of India's population ageing. The LASI is a full-scale, nationally representative survey that included 72,250 individuals aged 45 years and older and their spouses (irrespective of age) across all states and union territories (UTs) of India, except Sikkim. Data for the state of Sikkim were collected and incorporated into the LASI wave 1 dataset in April 2023. LASI uses multistage stratified area probability cluster sampling to select eventual units of observation. This study presents scientific evidence regarding chronic health conditions, biomarkers, symptom-based health conditions, and functional and mental health. The LASI survey was conducted using a three-stage sampling design in rural areas, and a four-stage sampling design in urban areas. In each state/UT, Primary Sampling Units (PSUs) were selected in the first stage, and villages in rural areas and wards in urban areas were selected in the second stage. In the third stage, households were selected from each selected village; however, sampling in urban areas involved an additional stage, i.e., the random selection of one Census Enumeration Block (CEB) in each urban area. In the

fourth stage, households were selected from each CEB. The main goal was to choose a representative sample at each stage of sample selection. The detailed methodology and extensive information on the survey's data collection is available in the report [23]. The data can be accessed by visiting the website https://g2aging.org/home, where users can register and request data access.

The present study is based on eligible respondents who are aged 60 years and above. The total sample size included in the current analysis was 31,386 older adults aged 60 years and above, including 15,043 males and 16,343 females. Our study had 842 missing cases for the frailty outcome variable, leaving 30,547 older adults for the multivariable analysis. A comparison of sociodemographic characteristics between the included and excluded samples revealed no statistically significant differences.

Measures

Outcome variable

Physical frailty was assessed using an adapted version of the frailty phenotype developed by Fried and colleagues [13]. Fried's frailty phenotype consists of five components: (1) self-reported exhaustion, (2) unintentional weight loss, (3) weak grip strength, (4) self-reported low physical activity, and (5) poor walkability. Exhaustion was estimated using two questions from the Center for Epidemiologic Studies Depression (CES-D) scale [24]: in the past week, how often did you feel "everything you did was an effort," and " felt tired or low in energy," answered by the respondents with "three or more days = 1" and "less than three days = 0." Unintentional weight loss was estimated using the question: "Do you think that you have lost weight in the last 12 months because there was not enough food in your household?" with responses "Yes = 1" and "No = 0." LASI measures handgrip strength in kilograms using a handheld Smedley Hand Dynamometer. The final handgrip strength score (kg) was calculated as the average score (kg) of two successive trials in the dominant hand and was adjusted for sex and body mass index. Weak grip strength in older men was defined as grip strength of 29 kg or less, 30 kg or less, and 32 kg or less for those with a BMI of 24 or less, 24.1 to 28, and > 28, respectively. Similarly, older women were classified as having weak grip strength if their grip strength was 17 kg or less, 17.3 kg or less, 18 kg or less, and 21 kg or less for those with BMI of 23 or less, 23.1 to 26, 26.1 to 19, and > 29, respectively.

Further, in LASI, respondents were asked about their engagement in vigorous physical activities: "How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health centre or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads: every day, more than once a week, once a week, one to three times a month, or hardly ever or never?" A single item on vigorous physical activity was considered while assessing the physical activity component of frailty in previous studies [25]. The low physical activity was defined as engaging in physical activity "one to three times a month or hardly ever or never", and code as 1. Finally, in LASI, respondents were asked to walk four meters twice, and slowness was estimated by averaging the time (in seconds) taken to complete the four meters (stratified by gender and height). Slow walk was defined with a sex-specific cut-off for different height measurements (≥ 7 s for males with a height of ≤ 173 cm and ≥ 6 s for males with a height of > 173 cm, and ≥ 7 s for females with a height of ≤ 159 cm and ≥ 6 s for males with a height of > 159 cm).

Finally, a composite physical frailty score of 0–5 was created by adding all the five indicators. Older participants were considered as robust if they scored zero in the scale of five; pre-frail if they scored one to three and frail if they scored four to five [13]. For the multivariable analysis, we focused on frail versus non-frail categories, where the non-frail group included pre-frail and robust individuals to simplify the interpretation.

Main explanatory variable

The main explanatory variable in this study was the self-reported age at the onset of chronic diseases among older adults. Respondents were asked, 'Has any health professional ever diagnosed you with the following diseases?'. The diseases were as follows: (1) hypertension or high blood pressure; (2) diabetes or high blood sugar; (3) heart attack or myocardial infarction; (4) chronic heart diseases; (5) stroke; (6) cancer or a malignant tumor; (7) chronic lung diseases such as asthma, chronic obstructive pulmonary disease/chronic bronchitis, or other chronic lung problems; (8) arthritis or rheumatism; (9) osteoporosis or other bone/joint diseases; and (10) psychiatric diseases. The question on diagnosis of specific disease was followed by a question on "When you were first diagnosed with particular disease?" The responses, from which the age at onset of chronic disease was calculated, were available in the form of years (in the exact year when the disease was diagnosed), a particular number of years before (year at respondents' birth plus number of years), and in the form of respondents' age at the time of diagnosis (current year during the survey subtracted by age at diagnosis). The variable was categorised into 'early onset of single disease', 'late onset of single disease', and 'early onset of multiple diseases' and 'late onset of multiple diseases.' The age at onset of chronic diseases was categorized into 'early' with a cut-off of 50 years or early, and 'late' if diagnosed after the age of 50 years. Although a cutoff of 50 years may be considered arbitrary, it is based

on studies that highlight distinct biological mechanisms, with stronger associations between chronic conditions such as hypertension, heart disease, mental disorders, and onset of disease at 50 years or later than early onset [26, 27].

Other covariates

Age was categorized as 60–69, 70–79, and 80 + years. Sex was coded as male and female. Education was categorised as no education, primary, secondary, and higher. Marital status was categorised as currently in a union, and currently not a union. Living arrangements were categorised as living alone, living with spouse and other living arrangements. Working status was categorised as never worked, currently working, currently not working, and retired. Alcohol drinking was coded as 'no', and 'yes'. Smoking tobacco and chewing tobacco were coded as 'no' and 'yes'. The BMI was computed by dividing the weight (in kilograms) by the square of the height (in meters). The BMI was categorised as normal, underweight, overweight, obese, and missing responses were coded as 'missing'. The monthly per capita expenditure quintile (MPCE) was assessed using household consumption data. MPCE was categorised into five quintiles, poorest, poor, middle, rich, and richest. Religion was coded as Hindu, Muslim, Christian, and Others. The social group (caste) was coded as Scheduled Castes, Scheduled Tribes, Other Backward Classes, and others. The 'other' category in caste is identified as having high social status. The place of residence was recoded as urban, and rural. The regions were coded as North, Central, East, Northeast, West, and South.

Statistical approach

We presented descriptive statistics at the initial stage to show the percentage distribution of the sample population by background characteristics and age at the onset (early/late) of chronic diseases. We conducted bivariate analysis to determine the prevalence of physical frailty among the study participants. Furthermore, we conducted maximum likelihood multivariable logistic regression models, controlling for the selected covariates, including age, sex, education, marital status, living arrangements, work status, alcohol drinking, smoking and chewing tobacco, BMI, wealth quintiles, religion, caste, place of residence, and regions to examine the association between early- and late-onset chronic diseases and physical frailty among older adults. Finally, multivariable logistic regression models were used to investigate the association of early and late onset of chronic diseases with each component of physical frailty. Additionally, logistic regression models were used to examine the association between the early and late onset of chronic diseases and physical frailty among older adults. The results are presented as Crude odds ratio (crude OR) and adjusted odds ratios (AOR) with 95% confidence intervals (CI). Individual weights were applied to account for the survey clustering and population estimates.

Results

Table 1 presents the sample characteristics and distribution by early/late onset of morbidity. A proportion of 11.3% of the participants were 80 years or older in this study. Approximately 53% of the sample population were females. A large proportion of the sample (56.8%) had no education, 61.5% were not married during the survey, and 5.7% of the participants were living alone. Furthermore, most of the sample belonged to rural areas (70.9%). About seven per cent of the sample population had early onset of a single disease, whereas 28.6% had late onset of a single disease. A proportion of 2.4% had both early and late onset of single morbidities. On the other hand, 2.1% of the participants had early onset of multiple diseases, whereas 19.7% had late onset of multiple diseases among older adults. This study had a few cases ($n = 53$) of both early and late onset of multiple diseases.

Figure 1 depicts the percentage distribution of older adults by their frailty status. Overall, 30.7% of the sample population were physically frail, whereas only 5.7% of the participants were not frail. The prevalence of frailty was much higher in the ≥ 80 years age group (54.2%).

Table 2 provides multivariable logistic regression estimates of physical frailty with early onset, late onset, and both early and late onset of single-and multimorbidity. Compared with individuals without any morbidity, individuals with late onset of single morbidity (AOR: 1.22, CI: 1.09–1.36) and multimorbidity (AOR: 1.49, CI: 1.29–1.71) were positively associated with physical frailty. Respondents with both early and late onset of a single morbidity (AOR: 1.50, CI: 0.96–2.33) were more likely to have physical frailty than their respective counterparts. Individuals with both early and late-onset multimorbidity (Crude OR: 1.70, CI: 0.98–2.98) were more likely to have physical frailty as compared with their respective counterparts; however, after adjusting for all covariates, there was no statistically significant association.

Table 3 presents the multivariable logistic regression estimates of each component of physical frailty by early onset, late onset, and both early and late onset of single-and multimorbidity. The odds of being exhausted were higher for respondents with late onset of single (AOR: 1.17, CI: 1.06–1.29) and multimorbidity (AOR: 1.35, CI: 1.18–1.54) than those without any morbidity. Individuals with both early and late onset of single morbidity (AOR: 1.55, CI: 1.06–2.27) were more likely to be exhausted, and those with both early and late-onset multimorbidity (AOR: 1.13, CI: 1.06–1.19) were more likely to be exhausted than their respective counterparts.

Table 1 Sample profile and early/late onset of single/multi- morbidity among older adults, longitudinal aging study in India (2017-18)

Variables	No chronic morbidity	Early onset of single morbidity	Late onset of single morbidity	Both early and late onset of single morbidity	Early onset multimorbidity	Late onset multimorbidity	Total sample, *n* (%)
Age							
60–69 years	9037 (61.8)	1593 (74.5)	5063 (55.6)	497 (68.4)	391 (65.3)	3219 (51.6)	18,933 (58.7)
70–79 years	4005 (27.4)	450 (21.0)	2929 (32.2)	189 (26.0)	191 (32.0)	2209 (35.4)	9076 (29.9)
80 + years	1569 (10.7)	94 (4.4)	1115 (12.2)	40 (5.6)	16 (2.7)	811 (13.0)	3377 (11.3)
Sex							
Male	7285 (49.9)	866 (40.5)	4107 (45.1)	304 (41.8)	203 (33.8)	2768 (44.4)	15,043 (47.2)
Female	7327 (50.1)	1271 (59.5)	5001 (54.9)	423 (58.2)	396 (66.2)	3471 (55.6)	16,343 (52.8)
Level of education							
No education	9341 (63.9)	811 (37.9)	4870 (53.5)	222 (30.6)	177 (29.6)	2898 (46.5)	16,860 (56.8)
Primary	2262 (15.5)	420 (19.7)	1795 (19.7)	177 (24.3)	84 (14.1)	1218 (19.5)	5824 (17.6)
Secondary	2164 (14.8)	633 (29.6)	1640 (18)	206 (28.3)	245 (40.8)	1503 (24.1)	6087 (17.9)
Higher	844 (5.8)	273 (12.8)	803 (8.8)	122 (16.8)	93 (15.5)	620 (9.9)	2615 (7.8)
Marital status							
Currently in a union	9211 (63)	1317 (61.6)	5488 (60.3)	459 (63.2)	380 (63.5)	3577 (57.3)	19,870 (61.5)
Currently not in a union	5401 (37)	820 (38.4)	3620 (39.7)	268 (36.8)	219 (36.5)	2662 (42.7)	11,516 (38.5)
Living arrangements							
Living alone	802 (5.5)	103 (4.8)	556 (6.1)	35 (4.9)	12 (2.0)	372 (6.0)	1620 (5.7)
Living with spouse	2913 (19.9)	445 (20.8)	1759 (19.3)	148 (20.4)	140 (23.5)	1221 (19.6)	6168 (19.9)
Other living arrangements	10,897 (74.6)	1590 (74.4)	6793 (74.6)	543 (74.7)	447 (74.6)	4646 (74.5)	23,598 (74.4)
Work status							
Never worked	3333 (22.8)	764 (35.7)	2505 (27.5)	266 (36.6)	282 (47.1)	2084 (33.4)	8771 (26.5)
Currently working	4858 (33.2)	663 (31.0)	3496 (38.4)	218 (29.9)	152 (25.4)	2574 (41.3)	10,954 (36.2)
Currently not working	5637 (38.6)	489 (22.9)	2358 (25.9)	159 (21.8)	108 (18)	961 (15.4)	8975 (30)
Retired	785 (5.4)	221 (10.3)	749 (8.2)	85 (11.7)	57 (9.6)	619 (9.9)	2686 (7.3)
Alcohol use*							
No	13,526 (92.6)	2042 (95.6)	8671 (95.2)	698 (96.0)	588 (98.2)	5989 (96.0)	29,537 (94.1)
Yes	1010 (6.9)	78 (3.6)	384 (4.2)	20 (2.8)	9 (1.4)	207 (3.3)	1669 (5.3)
Smoke tobacco*							
No	12,048 (82.4)	1873 (87.7)	7739 (85)	651 (89.5)	558 (93.2)	5348 (85.7)	26,350 (84)
Yes	2487 (17.0)	244 (11.4)	1319 (14.5)	67 (9.2)	38 (6.4)	846 (13.6)	4854 (15.5)
Chew tobacco*							
No	10,558 (72.3)	1660 (77.7)	6942 (76.2)	565 (77.7)	524 (87.5)	4909 (78.7)	23,521 (74.9)
Yes	3976 (27.2)	458 (21.4)	2116 (23.2)	153 (21.0)	72 (12.1)	1285 (20.6)	7684 (24.5)
Body mass index							
Normal	6921 (47.4)	823 (38.5)	4069 (44.7)	301 (41.4)	197 (32.9)	2488 (39.9)	14,521 (44.9)
Underweight	4487 (30.7)	250 (11.7)	1848 (20.3)	44 (6.0)	48 (8.0)	829 (13.3)	6524 (23.7)
Overweight	1351 (9.2)	621 (29.1)	1537 (16.9)	226 (31.1)	116 (19.4)	1423 (22.8)	5120 (14.6)
Obese	280 (1.9)	170 (7.9)	489 (5.4)	67 (9.3)	176 (29.4)	667 (10.7)	1633 (4.9)
Missing	1573 (10.8)	273 (12.8)	1165 (12.8)	89 (12.2)	61 (10.3)	832 (13.3)	3581 (12)
Household consumption quintiles							
Poorest	3725 (25.5)	265 (12.4)	1867 (20.5)	67 (9.3)	78 (13.0)	980 (15.7)	6465 (21.8)
Poor	3408 (23.3)	381 (17.8)	1937 (21.3)	115 (15.8)	75 (12.6)	1184 (19)	6459 (21.8)
Middle	3096 (21.2)	444 (20.8)	1867 (20.5)	165 (22.7)	90 (15.0)	1202 (19.3)	6399 (20.6)
Rich	2501 (17.1)	584 (27.3)	1897 (20.8)	177 (24.4)	112 (18.7)	1378 (22.1)	6160 (19.3)
Richest	1882 (12.9)	462 (21.6)	1539 (16.9)	202 (27.9)	244 (40.7)	1495 (24.0)	5903 (16.5)
Religion							
Hindu	12,334 (84.4)	1750 (81.9)	7430 (81.6)	597 (82.2)	499 (83.4)	4984 (79.9)	22,982 (82.5)
Muslim	1423 (9.7)	224 (10.5)	1084 (11.9)	78 (10.7)	59 (9.8)	775 (12.4)	3722 (10.9)
Christian	402 (2.7)	82 (3.8)	209 (2.3)	23 (3.2)	22 (3.6)	230 (3.7)	3141 (2.9)
Others	454 (3.1)	81 (3.8)	385 (4.2)	29 (4.0)	19 (3.2)	250 (4.0)	1541 (3.6)

Table 1 (continued)

Variables	No chronic morbidity	Early onset of single morbidity	Late onset of single morbidity	Both early and late onset of single morbidity	Early onset multimorbidity	Late onset multimorbidity	Total sample, *n* (%)
Social group							
SC	2987 (20.4)	301 (14.1)	1711 (18.8)	82 (11.3)	59 (9.9)	1033 (16.6)	5128 (19)
ST	1662 (11.4)	80 (3.8)	576 (6.3)	32 (4.4)	12 (2.0)	250 (4.0)	5162 (8.1)
OBC	6470 (44.3)	1007 (47.1)	4038 (44.3)	320 (44.0)	327 (54.6)	2988 (47.9)	11,854 (45)
Others	3492 (23.9)	749 (35.0)	2784 (30.6)	293 (40.3)	201 (33.6)	1967 (31.5)	9242 (27.9)
Residence							
Urban	2999 (20.5)	1058 (49.5)	3022 (33.2)	386 (53)	364 (60.8)	2569 (41.2)	10,695 (29.1)
Rural	11,613 (79.5)	1079 (50.5)	6086 (66.8)	341 (47)	235 (39.2)	3670 (58.8)	20,691 (70.9)
Region							
North	1695 (11.6)	246 (11.5)	1272 (14)	71 (9.7)	52 (8.7)	822 (13.2)	5800 (12.6)
Central	4063 (27.8)	247 (11.6)	1548 (17)	80 (11.0)	51 (8.5)	765 (12.3)	4259 (21.1)
East	3695 (25.3)	422 (19.8)	1974 (21.7)	142 (19.6)	86 (14.3)	1492 (23.9)	5751 (23.8)
Northeast	504 (3.5)	48 (2.3)	274 (3.0)	15 (2.0)	6 (1.1)	119 (1.9)	3746 (3)
South	2526 (17.3)	725 (33.9)	2268 (24.9)	252 (34.7)	268 (44.7)	1865 (29.9)	7547 (22.3)
West	2129 (14.6)	449 (21.0)	1772 (19.5)	167 (23)	136 (22.7)	1175 (18.8)	4283 (17.2)
Total	**14,612 (46.56)**	**2137 (6.87)**	**9108 (28.62)**	**727 (2.41)**	**599 (2.14)**	**6239 (19.71)**	**31,386**

Notes: * Sample size and percentages may differ due to missing cases; Total number of cases in the category of 'both early and late onset 'multimorbidity' was 53; SC: Scheduled caste; ST: Scheduled tribe; OBC: Other backward classes

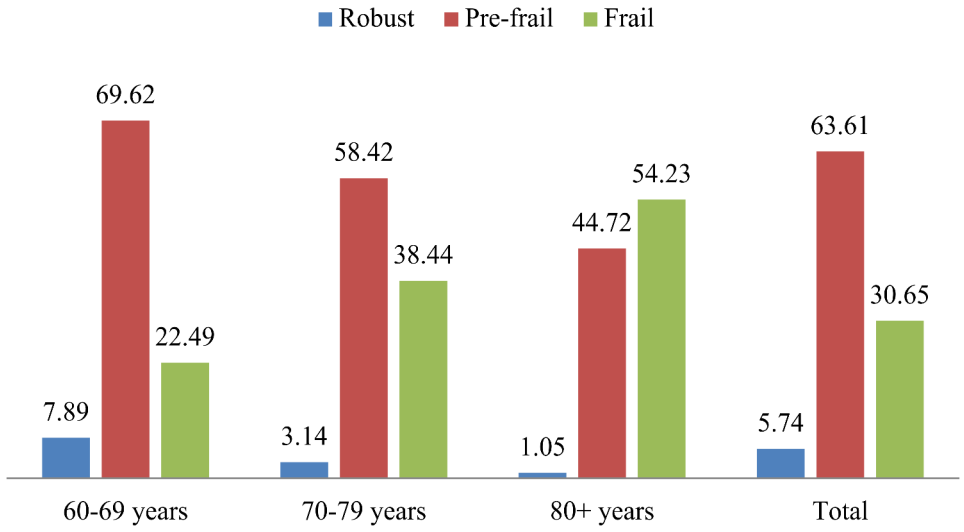

Fig. 1 Percentage distribution of older adults by physical frailty

Respondents with early onset multimorbidity (AOR: 1.47, CI: 1.01–2.14) were more likely to have weak grip strength, while those with late-onset multimorbidity (AOR: 1.32, CI: 1.13–1.53) were more likely to have weak grip strength than those without any chronic disease. Respondents with both early- and late-onset multimorbidity (AOR: 2.25, CI: 2.10–2.41) had higher odds of weak grip strength than their counterparts. Individuals with early onset multimorbidity (AOR: 1.40, CI: 0.96–2.05) were more likely to be physically inactive, while those with late-onset multimorbidity (AOR: 1.26, CI: 1.07–1.47) were more likely to be physically inactive than individuals without any morbidity. Respondents with early- and late-onset multimorbidities (AOR: 1.35, CI: 1.26–1.45) were more likely to be physically inactive than their counterparts. Individuals with late onset of single morbidity (AOR: 1.36, CI: 1.13–1.64) and multimorbidity (AOR: 1.64, CI: 1.28–2.09) were more likely to have weight loss, while individuals with early onset of single morbidity (AOR: 0.64, CI: 0.43–0.95) were less likely to have weight loss than individuals without any chronic disease. The odds of poor walkability were higher among the respondents with late onset of single (AOR: 1.19, CI: 1.04–1.37) and multimorbidity (AOR: 1.41, CI:

Table 2 Association of early and late onset of chronic morbidity with physical frailty

Onset of morbidity	Physical frailty	
	Crude OR (95% CI)	Adjusted OR (95% CI)
Early onset of morbidity		
No morbidity	Ref.	Ref.
Single morbidity	0.82 (0.62–1.07)	1.10 (0.85–1.42)
Multimorbidity	0.68 (0.34–1.33)	0.79 (0.33–1.87)
Late onset of morbidity		
No morbidity	Ref.	Ref.
Single morbidity	1.28** (1.16–1.42)	1.22** (1.09–1.36)
Multimorbidity	1.64*** (1.44–1.87)	1.49*** (1.29–1.71)
Both early and late onset of morbidity		
Both early and late onset of single morbidity		
No	Ref.	Ref.
Yes	1.13 (0.78–1.65)	1.50* (1.00–2.33)
Both early and late onset of multiple morbidity		
No	Ref.	Ref.
Yes	1.70* (1.00–2.98)	1.59 (0.86–2.93)
Age		
60–69 years		
70–79 years		1.74*** (1.55–1.95)
80 + years		3.25*** (2.68–3.93)
Sex		
Male		
Female		0.98 (0.87–1.12)
Education		
No education		
Primary		1.00 (0.87–1.14)
Secondary		0.73*** (0.61–0.87)
Higher		0.62*** (0.51–0.77)
Marital status		
Currently in a union		
Currently not in a union		1.21* (1.07–1.38)
Living arrangements		
Living alone		
Living with spouse		0.85 (0.66–1.08)
Other living arrangements		0.78* (0.63–0.96)
Work status		
Never worked		
Currently working		1.45*** (1.26–1.66)
Currently not working		0.43*** (0.37–0.50)
Retired		0.95 (0.76–1.19)
Alcohol use		
No		
Yes		0.94 (0.74–1.21)
Smoke tobacco		
No		
Yes		0.96 (0.82–1.11)
Chew tobacco		
No		
Yes		0.92 (0.82–1.03)
Body mass index		
Normal		
Underweight		1.45*** (1.30–1.63)
Overweight		0.94 (0.80–1.09)

Table 2 (continued)

Onset of morbidity	Physical frailty	
	Crude OR (95% CI)	Adjusted OR (95% CI)
Obese		1.11 (0.81–1.52)
Household consumption quintiles		
Poorest		
Poor		0.96 (0.84–1.09)
Middle		0.99 (0.86–1.14)
Rich		0.91 (0.78–1.07)
Richest		1.07 (0.89–1.29)
Religion		
Hindu		
Muslim		1.18* (1.03–1.36)
Christian		1.07 (0.85–1.35)
Others		0.94 (0.76–1.17)
Social group		
SC		
ST		0.91 (0.75–1.11)
OBC		0.93 (0.82–1.06)
Others		0.95 (0.82–1.10)
Residence		
Urban		
Rural		1.01 (0.89–1.15)
Region		
North		
Central		1.40*** (1.21–1.62)
East		1.56*** (1.35–1.79)
Northeast		0.92 (0.78–1.10)
South		1.29* (1.09–1.53)
West		0.99 (0.85–1.15)
Observation	30,545	27,759
Pseudo R2	0.01	0.11

Notes: Adjusted OR: Odds ratio adjusted for all the selected covariates; CI: Confidence interval, * if $p<0.05$, ** if $p<0.01$, *** if $p<0.001$; SC: Scheduled caste; ST: Scheduled tribe; OBC: Other backward classes

1.20–1.66) than those without any morbidity. Respondents with both early- and late-onset multimorbidity (AOR: 2.40, CI: 2.24–2.58) had higher odds of poor walkability, and those with both early- and late-onset single morbidity (AOR: 1.66, CI: 0.96–2.87) were more likely to have poor walkability than their respective counterparts.

Table 4 provides the multivariable logistic regression estimates of physical frailty by early and late onset of each morbidity compared to no morbidity in this study. Individuals with early onset of heart disease (AOR: 0.44, CI: 0.19–0.99) had lower odds of physical frailty, while individuals with late-onset heart disease (AOR: 1.58, CI: 1.21–2.06) were more likely to have physical frailty than individuals without any chronic disease. Respondents with late-onset hypertension (AOR: 1.22, CI: 1.09–1.36) and stroke (AOR: 1.75, CI: 1.35–2.27) were more likely to be physically frail than the respondents without any morbidity. The odds of being physically frail were higher in the early onset of arthritis (AOR: 1.55, CI: 1.15–2.08) and in the late onset of arthritis (AOR: 1.35, CI: 1.13–1.61) compared with individuals without any morbidity.

Table 5 provides the multivariable logistic regression estimates of physical frailty by late-onset of each morbidity compared with the early onset of the respective morbidities. After adjusting for the selected covariates, individuals with late-onset heart disease (AOR: 3.39, CI: 1.31–8.77) and psychiatric disease (AOR: 3.00, CI: 1.19–7.61) had higher odds of physical frailty than those with early onset of their respective counterparts. Respondents with late-onset hypertension (Crude OR: 1.51, CI: 1.00–2.29) and chronic lung disease (Crude OR: 1.68, CI: 1.12–2.51) were more likely to be physically frail than those with early-onset of their respective counterparts; however, after adjusting for the covariates, there was no statistically significant association.

Table 3 Association of early and late onset of chronic morbidity with components of physical frailty

Onset of morbidity	Exhausted	Weak grip strength	Poor walkability	Weight loss	Physically inactive
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Early onset of morbidity					
No morbidity	Ref.	Ref.	Ref.	Ref.	Ref.
Single morbidity	1.13 (0.88–1.45)	1.06 (0.83–1.37)	1.17 (0.87–1.57)	0.64* (0.43–0.95)	1.08 (0.81–1.43)
Multimorbidity	0.88 (0.49–1.57)	1.47* (1.01–2.14)	0.74 (0.28–1.93)	0.95 (0.43–2.07)	1.40* (1.00–2.05)
Late onset of morbidity					
No morbidity					
Single morbidity	1.17* (1.06–1.29)	1.03 (0.92–1.16)	1.19* (1.04–1.37)	1.36** (1.13–1.64)	1.05 (0.91–1.20)
Multimorbidity	1.35*** (1.18–1.54)	1.32*** (1.13–1.53)	1.41*** (1.20–1.66)	1.64*** (1.28–2.09)	1.26** (1.07–1.47)
Both early and late onset of morbidity					
Both early and late onset of single morbidity					
No	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	1.55* (1.06–2.27)	0.92 (0.59–1.43)	1.66* (1.00–2.87)	0.85 (0.42–1.71)	1.08 (0.55–2.13)
Both early and late onset of multiple morbidity					
No	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	1.13** (1.06–1.19)	2.25*** (2.10–2.41)	2.40*** (2.24–2.58)	0.99 (0.87–1.13)	1.35*** (1.26–1.45)

Notes: Adjusted OR: Odds ratio adjusted for all the selected covariates, CI: Confidence interval, * if $p < 0.05$, ** if $p < 0.01$, *** if $p < 0.001$

Table 4 Association of early and late onset of each chronic morbidity with physical frailty

Onset of morbidity	Physical frailty
	Adjusted OR (95% CI)
Early onset of each disease (Ref: no disease)	
Hypertension	1.05 (0.66–1.66)
Diabetes	0.73 (0.34–1.59)
Heart attack	1.08 (0.55–2.12)
Heart disease	0.44* (0.19–0.99)
Stroke	0.93 (0.39–2.22)
Cancer	0.33 (0.054–2.02)
Lung disease	1.09 (0.77–1.54)
Arthritis	1.55** (1.15–2.08)
Osteoporosis	1.58 (0.73–3.43)
Psychiatric diseases	0.63 (0.29–1.37)
Late onset of each disease (Ref: no disease)	
Hypertension	1.22** (1.09–1.36)
Diabetes	1.14 (0.97–1.34)
Heart attack	0.84 (0.48–1.48)
Heart disease	1.58** (1.21–2.06)
Stroke	1.75*** (1.35–2.27)
Cancer	0.94 (0.55–1.62)
Lung disease	1.25 (0.94–1.66)
Arthritis	1.35** (1.13–1.61)
Osteoporosis	1.50*** (1.21–1.84)
Psychiatric diseases	1.90*** (1.48–2.42)

Notes: Adjusted OR: Odds ratio adjusted for all the selected covariates, CI: Confidence interval, * if $p < 0.05$, ** if $p < 0.01$, *** if $p < 0.001$

Discussion

The present study investigated the prevalence of early- and late-onset chronic morbidity and its association with physical frailty and its components among older adults in India using nationally representative large-scale data of LASI-wave-1. According to our findings, 6.87% of older persons had early onset, and 28.62% had late onset of any morbidity. Additionally, approximately 2.14% of older adults had early onset, and 19.71% had late-onset multimorbidity. Our findings further suggest that compared to individuals without any morbidity, individuals with late-onset single morbidity and multimorbidity were associated with physical frailty. Particularly, late-onset heart disease and psychiatric conditions were associated with frailty in this study. These results highlight the need for timely diagnosis and management of these specific conditions, which could play a crucial role in preventing frailty in later life. Although few studies have explored the prevalence and associated factors of early- and late-onset morbidity, our study is among the first to demonstrate the robust association of early- and late-onset chronic morbidity with physical frailty among older adults. Previous studies suggest a strong association between the onset of chronic morbidities [28–31] and aspects of the social and economic environments in which older adults live [32]. Prior research also suggests that multimorbidity in older people is strongly associated with an increased risk of physical frailty, which may be evident at a young age [33].

Furthermore, a recent study [34] demonstrated that frailty is related to a more significant burden and duration of heart failure symptoms as well as a lower health

Table 5 Association of early / late onset of morbidity with physical frailty

Onset of morbidity	Physical frailty	Physical frailty
	Crude OR (95% CI)	Adjusted OR (95% CI)
Age at onset of hypertension (*n* = 10,575)		
Early onset	Ref.	Ref.
Late onset	1.51* (1.00–2.29)	1.13 (0.77–1.66)
Age at onset of diabetes (*n* = 4,711)		
Early onset	Ref.	Ref.
Late onset	1.66* (1.00–2.90)	1.32 (0.77–2.25)
Age at onset of heart attack (*n* = 833)		
Early onset	Ref.	Ref.
Late onset	1.58 (0.71–3.51)	1.12 (0.47–2.68)
Age at onset of heart disease (*n* = 679)		
Early onset	Ref.	Ref.
Late onset	4.87*** (2.05–11.6)	3.39** (1.31–8.77)
Age at onset of stroke (*n* = 734)		
Early onset	Ref.	Ref.
Late onset	1.71 (0.75–3.87)	2.00 (0.80–4.98)
Age at onset of cancer (*n* = 227)		
Early onset	Ref.	Ref.
Late onset	2.37 (0.53–10.6)	2.34 (0.28–19.4)
Age at onset of lung disease (*n* = 4,201)		
Early onset	Ref.	Ref.
Late onset	1.68** (1.12–2.51)	1.32 (0.91–1.91)
Age at onset of arthritis (*n* = 1,410)		
Early onset	Ref.	Ref.
Late onset	1.25 (0.91–1.72)	0.97 (0.70–1.34)
Age at onset of osteoporosis (*n* = 729)		
Early onset	Ref.	Ref.
Late onset	1.37 (0.63–2.98)	0.73 (0.35–1.54)
Age at onset of psychiatric diseases (*n* = 2,249)		
Early onset	Ref.	Ref.
Late onset	4.42*** (1.96–9.97)	3.00** (1.19–7.61)

Notes: Adjusted OR: Odds ratio adjusted for all the selected covariates, CI: Confidence interval, * if $p < 0.05$, ** if $p < 0.01$, *** if $p < 0.001$

status in individuals with ambulatory heart diseases. Consistently, we found that older individuals with late-onset stroke and heart disease have a greater risk of being physically frail compared to those without any morbidity, as also observed in other research [19, 35]. Unfortunately, late-onset of hypertension is another condition that impairs everyday activities in older population [36] and the prevalence of hypertension in frail individuals can reach up to 80%, and it appears to be substantially related to decreased cognitive function and sedentary behaviours [37]. Consistently, our findings suggest that older persons with late-onset hypertension are more likely to be physically frail than those without such condition. Our findings are also consistent with previous studies [20, 38, 39] that suggest that physical frailty is more prevalent among patients with arthritis. This association may be attributed to the slow walking and low physical activity components of physical frailty.

Although physical frailty is a significant issue that is exacerbated by ageing, it is also a crucial geriatric health indicator that may be used to manage the health and well-being of older populations. Moreover, when older people engage in less physical activity, they are more likely to be frail or exhibit pre-frailty. Hence, there is a need to encourage older adults with chronic conditions to participate in intellectual activities, such as playing chess or other games with other people, or engaging in social activities, such as yoga practice, which could be a practical approach to prevent physical frailty. According to the existing literature, lack of formal education is highly prevalent in older populations, particularly in low- and middle-income countries (LMICs), and can also predict physical frailty [28]. A prior study found that education levels considerably influenced frailty in older persons [40] and our findings showed that older adults with secondary and higher educational levels have a significantly lower risk of physical frailty than older adults with no education. This may be due to the existence of several vulnerabilities among older adults with low education, such as malnutrition [41], immobile conditions and poor health behavior, all of which will contribute to the increased prevalence of comorbidities [42].

Implications of the study findings

The early detection and proactive management of chronic diseases can help mitigate their progression and delay the onset of frailty. Identifying frail persons is a critical step in avoiding unpleasant consequences, providing proper healthcare and support, and successfully preventing and delaying the development of frailty by health professionals. It is particularly significant since it is linked to dependence and complications following procedures and medical treatments, and an increased risk of multiple chronic diseases and mortality. We identified that less-educated individuals were more likely to be frail, suggesting that preventative interventions should target this group. Interventions promoting healthy ageing, such as routine health screenings, lifestyle modifications, and early disease-specific interventions, can play a pivotal role in reducing frailty prevalence.

Subsequently, modifiable adverse lifestyles cause many chronic conditions, and treatments aimed at improving lifestyle may open up new avenues for frailty prevention

in the future. Tailored interventions addressing physical activity, nutrition, and psychosocial support can help target frailty components and improve the overall health outcomes in older adults. However, longitudinal studies should be undertaken to understand how lifestyle and associated comorbidities influence frailty development and its dynamic course. Furthermore, successfully addressing frailty associated with multimorbidity involves enhanced knowledge and recognition by healthcare practitioners and professional doctors, including risk prediction models when treating an aged frail patient with an underlying complicated chronic illness, and early referral for complete geriatric treatment.

Strengths and limitations

The strength of our study is that we analysed nationally representative data that included a large sample of older adults. Moreover, given the exhaustible information on participants' socioeconomic and health conditions, we adjusted for a large number of potential confounders in the study. However, there are some limitations to be acknowledged in this study. Notably, the study's cross-sectional design prevents conclusions from being drawn about causality in the observed associations. In addition, the self-reported nature of the key variable on age at onset of chronic diseases may result in recall and reporting biases and influence the current findings. The self-report of morbidity is mired by gross under-reporting in LMICs such as India. Studies based on such self-reports can produce biased and misleading results; therefore, they must be interpreted cautiously. In addition, many of the variables were dichotomized, including the key predictor variable of age at onset (with a cutoff point of 50), which needs to be considered while interpreting the results.

Indeed, the operationalization of the frailty phenotype construct is limited, as it is based on an adaptation of Fried's frailty phenotype. The original frailty phenotype specifies unintentional weight loss (seeking to characterize a physical phenomenon). LASI equivalent variable was weight loss owing to insufficient food availability. While this is undoubtedly associated with health risks, it is not quite the same phenomenon. It is likely to be driven (in many cases) by social and financial circumstances rather than being an accurate marker of 'frailty.' These should be considered when interpreting the current findings. Finally, several unobserved factors, such as socio-cultural and genetic factors, were not considered in the current analysis, which can also bias the results of our study.

Conclusions

The study found significant positive associations between early and late onset of chronic diseases and physical frailty among older Indian adults. The findings underscore the importance of managing late-onset chronic diseases, especially heart disease and psychiatric conditions, to mitigate frailty in older adults. These findings suggest that delayed detection and management of chronic conditions may exacerbate vulnerability in older adults, and age at onset of chronic diseases can be used to identify the subpopulation at increased risk of physical frailty. These findings highlight the critical role of multimorbidity in influencing multiple components of physical frailty, suggesting that comprehensive interventions targeting both physical and mental health components could help delay or prevent frailty.

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Author contributions

Conceived and designed the research paper: TM and WA; analysed the data: TM and WA; Wrote the manuscript: WA, TM, SNA and WKA. All authors read, reviewed, and approved the manuscript. All authors read and approved the final version of the manuscript.

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Data availability

All data generated or analysed during this study are publicly available and accessible from the repository of The Gateway to Global Aging Data (https://g2aging.org/).

Declarations

Ethics approval and consent to participate

The study was approved by the Indian Council of Medical Research (ICMR) Ethics Committee in January 2017, and written or oral informed consent was obtained from the participants. All methods were carried out in accordance with relevant guidelines and regulations and in accordance with the World Medical Association Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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