Gerontology

Clinical Section

Gerontology 2025;71:81–87
DOI: 10.1159/000543378

Received: April 5, 2024
Accepted: December 25, 2024
Published online: January 2, 2025

Trajectories of Instrumental Activities of Daily Living and Their Predictors among Older Men and Women in Hong Kong: A 14-Year Prospective Study

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Keywords
Instrumental activities of daily living impairment · Trajectories · Group-based modeling · Older people

Abstract
Introduction: This study aimed to identify the different patterns of trajectories in instrumental activities of daily living (IADL) in older men and women, respectively, and to examine the factors associated with the different trajectories. ***Methods:*** We included 2,088 participants with an average age of 70.8 years at baseline from the MrOS and MsOS Hong Kong cohort study (men: 1,074; women: 1,014) and followed up the participants for over 14 years. The group-based trajectory models were used to identify IADL trajectories. Binary logistic regression and multinominal logistic regression models were used to identify factors associated with different trajectories. ***Results:*** Two distinct trajectories were identified for men including "slow decliners" (92.6% of men) and "rapid decliners" (7.4%), while three distinct trajectories were identified for women including "slow decliners" (43.5% of women), "intermediate decliners" (48.2%), and "rapid decliners" (8.3%). Being overweight or obese and slow walking speed were common predictors of more rapid IADL declining trajectories in both men and women. Particularly, having stroke, weak grip strength, and higher level of $PM_{2.5}$ were associated with the higher risk of being rapid decliners in men, and having osteoporosis and poor self-rated health were associated with more rapid IADL declining trajectories in women. ***Conclusion:*** Sex differences were observed in the IADL declining trajectories. Several risk factors were found that could possibly be useful in identifying and preventing functional impairments in an earlier stage.

Introduction

As the life expectancy has increased globally, a rising burden of disability at old age has become an important public health challenge [1]. Disability in older adults leads

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to an increase in healthcare utilization and healthcare expenditure [2]. To maintain independence and prevent functional disability throughout the life course, it is crucial to understand the dynamic of the disability progress and identify potential contributing factors.

Several studies have examined the trajectory pattern of disability in older adults [3–6], but disability in these studies was assessed only by the basic activity of daily living (ADL) which measures the essential self-care activities. Different from ADL, instrumental activity of daily living (IADL) incorporates more complex activities involving both physical and cognitive skills that are related to independent living in the community, so people usually had IADL impairments before ADL deficits [7]. Therefore, it is important to explore the change in IADL over time to prevent future dependence in an earlier stage.

There is evidence suggesting that older women in general experienced greater disability than older men [8]. However, whether the development of functional impairments measured by IADL in men and women follows different trajectories and whether the factors contributing to the trajectories of functional impairments differ by sex remain largely uncertain. Furthermore, the risk factors for the declining functional trajectories identified in existing studies were mainly individual factors [3–6]. Environmental factors such as air pollution, the leading environmental risk factor contributing to morbidity and mortality [9], have rarely been evaluated in relation to the trajectories of functional impairments over time. To bridge the above gaps, this study aimed to identify distinct trajectories of IADL for men and women and to examine the predictors of the identified IADL trajectories among a cohort of community-dwelling older people living in Hong Kong with a follow-up period of up to 14 years.

Methods

Study Participants

The present analysis was carried out in the MrOS and MsOS Hong Kong cohort study, a prospective cohort study that consisted of 4,000 community-dwelling men and women aged 65 years old and above in Hong Kong since 2001. The IADL function was measured at baseline (2001–2003), year 7 follow-up visit (2008–2010), and year 14 follow-up visit (2015–2017). We excluded participants who have not been followed up in either year 7 visit or year 14 visit due to the inability to measure changes in their IADL function, resulting in a final analysis sample of 2,088 participants.

Instrumental Activity of Daily Living

The IADL function measured five items including ability of "walking 2-3 blocks," "climbing 10 steps," "preparing own meals, "doing heavy housework," and "doing own shopping." Participants were asked to score the five items on a 4-point scale (0 = no difficulty, 1 = a little difficulty, 2 = much difficulty, and 3 = unable to carry out). A total score (range from 0 to 15) of the five items indicating the degree of impairment will be calculated, with higher scores indicating a higher level of IADL impairment.

Potential Factors

To examine the factors associated with the IADL trajectories, the baseline characteristics of the participants including sociodemographics (i.e., age, sex, educational level, and marital status), health condition, lifestyle, and physical performance were assessed by a standardized questionnaire interview and a battery of physical assessments. Self-reported physician-diagnosed chronic diseases included diabetes mellitus, stroke, heart diseases (coronary heart disease, heart failure, or myocardial infarction), arthritis, and osteoporosis. Cognitive function was assessed with the Mini-Mental State Examination (MMSE). Depressive symptoms were assessed using the 15-item Chinese version of the Geriatric Depression Scale (GDS-15). Self-rated health was assessed by "How would you rate your overall health: excellent, good, fair, poor, or very poor?." Smoking was categorized as "current smoker" or "non-current smoker." Physical activity was assessed by the validated Physical Activity Scale for the Elderly (PASE) Questionnaire. Body mass index (BMI) was calculated from measured weight and height (kg/m^2) and categorized as underweight (<18.5 kg/m^2), normal weight (18.5–25 kg/m^2), or overweight or obese (BMI ≥25 kg/m^2). Gait speed was measured by asking the participants to complete a 6-meter walkway at a normal pace. Grip strength was measured using a dynamometer (JAMAR Hand Dynamometer 5030JO; Sammons Preston). Because the particulate air pollutants $PM_{2.5}$ is one of the most influential environmental risk factors of disability, $PM_{2.5}$ in the participants' residential area was estimated by a land use regression models [10].

Statistical Analysis

We used a group-based trajectory modeling approach to identify trajectories of IADL function. The best-fitting model with the optimal numbers of trajectories was chosen based on the following criteria: the model with the

Table 1. Baseline characteristics between men and women (n = 2,088)

	Men, n = 1,074	Women, n = 1,014	p value
IADL function	0.2±0.7	0.7±1.5	<0.001
Sociodemographic factors			
Age	71±4.3	70.7±4.3	0.209
Education level			<0.001
Primary or below	591 (55%)	795 (78.4%)	
Secondary or above	483 (45%)	219 (21.6%)	
Marital status			<0.001
Married	981 (91.3%)	616 (60.7%)	
Not married	93 (8.7%)	398 (39.3%)	
Health condition			
Diabetes mellitus	135 (12.6%)	132 (13%)	0.759
Stroke	47 (4.4%)	28 (2.8%)	0.048
Heart diseases	118 (11%)	122 (12%)	0.454
Arthritis	97 (9%)	145 (14.3%)	<0.001
Osteoporosis	24 (2.2%)	84 (8.3%)	<0.001
MMSE scores	27.5±2.4	25.3±3.5	<0.001
GDS scores	2.6±2.6	2.6±2.6	0.718
Self-rated health			<0.001
Poor/very poor/fair	386 (35.9%)	621 (61.2%)	
Good/excellent	688 (64.1%)	393 (38.8%)	
Lifestyle factors			
Current smokers	99 (9.2%)	16 (1.6%)	<0.001
PASE total scores	104.8±50.7	89.1±33.8	<0.001
BMI			0.013
Underweight	41 (3.8%)	32 (3.2%)	
Normal weight	712 (66.3%)	618 (60.9%)	
Overweight or obese	321 (29.9%)	364 (35.9%)	
Physical performance			
Grip strength	35.5±6.4	23.1±4.4	<0.001
Gait speed	1.1±0.2	1.0±0.2	<0.001
Environmental factors			
Concentration of $PM_{2.5}$	32.6±2.3	32.5±2.4	0.797

MMSE, Mini-Mental State Examination; GDS, Geriatric Depression Scale; PASE, Physical Activity Scale for the Elderly.

lowest Bayesian Information Criterion (BIC), the model with a minimum average posterior probability of 0.7 for each trajectory group [11], and at least 5% of participants in each trajectories.

Differences in baseline characteristics between men and women were compared using independent t tests and chi-square test whenever appropriate. To identify the baseline factors associated with the identified IADL trajectories, binary logistic regression and multinomial logistic regression were used to estimate the odds ratios and the 95% confident intervals. A SAS procedure (PROC TRAJ) was used to conduct the group-based trajectory modeling. The other statistical analysis was conducted using the statistical package SPSS v 26 (SPSS, Inc). p values <0.05 were considered statistically significant.

Results

Baseline Characteristics

The comparison of baseline characteristics between men and women are presented in Table 1. As compared to men, women were less educated, were unmarried, had more chronic conditions such as arthritis, osteoporosis, and cognitive decline, reported poorer self-rated health, and had poorer grip strength and slower 6-meter walking speed (all p value <0.05).

Trajectories of IADL Function

The best-fitting models of the trajectories of IADL function were a two-group model for men and a three-group model for women (Fig. 1). The IADL function for

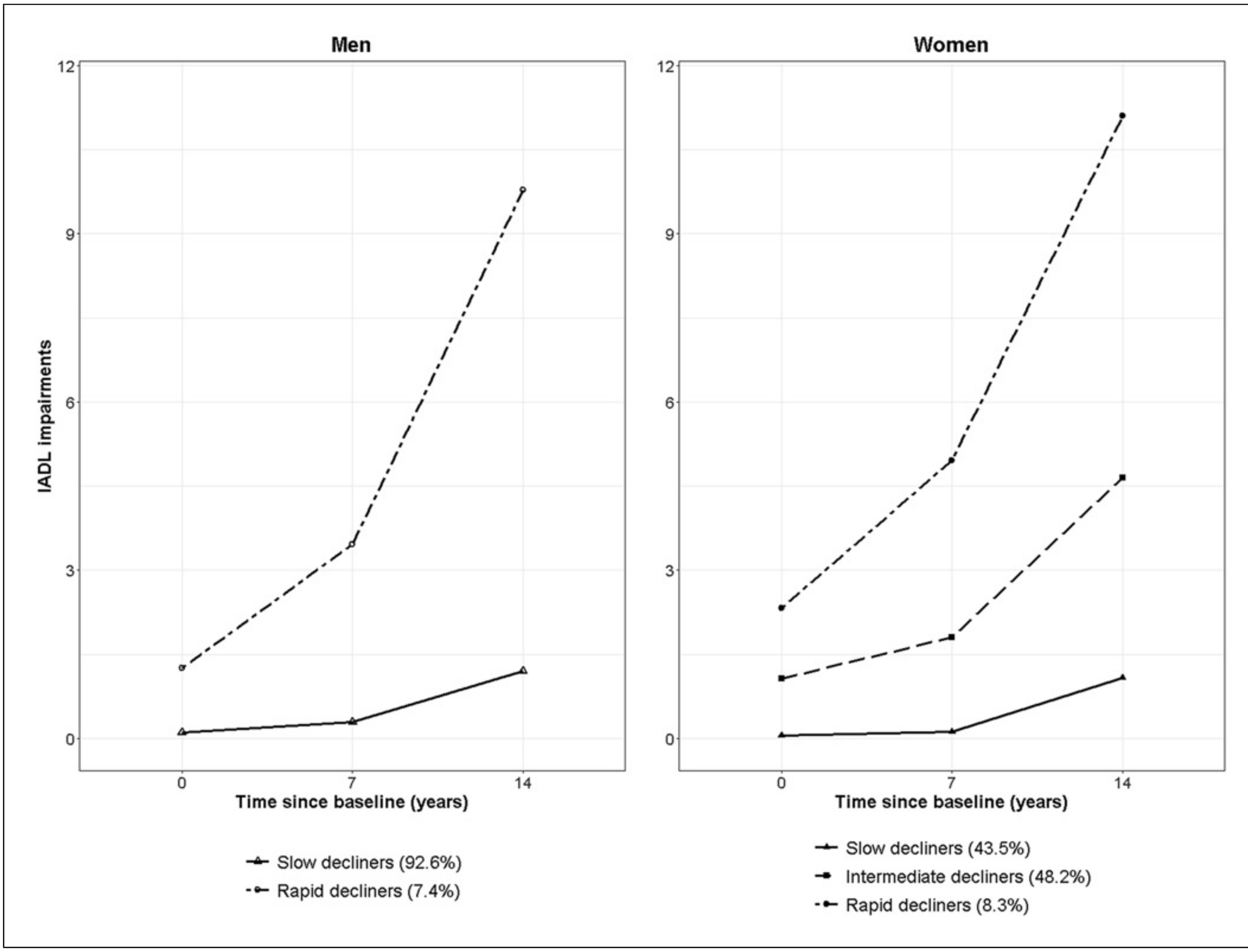

Fig. 1. Trajectories of the IADL function over 14 years among older men and women.

both men and women declined over time at an accelerated rate in all trajectory groups.

The two trajectory groups identified for men were "slow decliners" (995 [92.6%]) and "rapid decliners" (79 [7.4%]). Men in the "slow decliners" group maintained intact IADL at baseline, but their IADL function was slightly impaired over the follow-up period. Men who were "rapid decliners" were modestly impaired at baseline and experienced substantially rapid decline in IADL in the subsequent 14 years.

In older women, the IADL trajectory that occurred most frequently was "intermediate decliners" (489 [48.2%]), followed by "slow decliners" (441 [43.5%]) and "rapid decliners" (84 [8.3%]). Both women being "intermediate decliners" or "rapid decliners" were slightly impaired in IADLs at baseline, but the IADL function of women being "intermediate decliners" declined less markedly compared to those who were "rapid decliners."

Factors Associated with Different IADL Trajectories

Table 2 showed the associations between potential risk factors and the different IADL trajectories by men and women, separately. Being overweight or obese and slow walking speed were significant predictors of more rapid IADL declining trajectories in both men and women. Additionally, having diabetes, stroke, and arthritis, being more depressed, weaker handgrip strength, and exposing to higher level of $PM_{2.5}$ in older men were associated with being rapid decliners. Poor self-rated health was associated with intermediate decline and rapid decline when compared to slow decline in women. Younger age and

Table 2. Associations between baseline predictors and the IADL trajectories in men and women

	Men		Women			
	rapid decliners versus slow decliners		intermediate decliners versus slow decliners		rapid decliners versus slow decliners	
	odds ratio (95% CI)	*p* value	odds ratio (95% CI)	*p* value	odds ratio (95% CI)	*p* value
Sociodemographic factors						
Age	0.95 (0.89, 1.01)	0.099	0.99 (0.95, 1.02)	0.467	**0.89 (0.83, 0.95)**	**0.001**
Primary or below education	1.49 (0.89, 2.49)	0.13	1.04 (0.72, 1.49)	0.847	1.30 (0.67, 2.52)	0.44
Married	0.40 (0.13, 1.21)	0.104	0.98 (0.72, 1.31)	0.866	0.87 (0.51, 1.51)	0.629
Health condition						
Diabetes mellitus	**1.94 (1.06, 3.55)**	**0.033**	1.16 (0.76, 1.76)	0.497	**2.25 (1.15, 4.40)**	**0.018**
Stroke	**2.36 (1.04, 5.36)**	**0.04**	1.23 (0.51, 2.98)	0.64	1.12 (0.27, 4.74)	0.876
Heart diseases	1.12 (0.54, 2.34)	0.765	1.19 (0.77, 1.83)	0.442	0.91 (0.42, 1.97)	0.815
Arthritis	**2.00 (1.01, 3.94)**	**0.046**	1.29 (0.85, 1.95)	0.235	**2.27 (1.22, 4.22)**	**0.01**
Osteoporosis	1.49 (0.4, 5.52)	0.555	1.24 (0.74, 2.08)	0.42	**2.36 (1.09, 5.11)**	**0.03**
MMSE scores	1.02 (0.92, 1.13)	0.753	1.00 (0.96, 1.05)	0.838	1.03 (0.95, 1.11)	0.545
GDS scores	1.09 (0.99, 1.19)	0.055	1.01 (0.96, 1.07)	0.636	1.07 (0.97, 1.17)	0.164
Lifestyle factors						
Current smokers	1.49 (0.69, 3.26)	0.312	1.78 (0.60, 5.33)	0.3	1.96 (0.20, 18.86)	0.56
PASE total scores	1.00 (0.99, 1.00)	0.281	1.00 (0.99, 1)	0.078	1.00 (0.99, 1.01)	0.72
BMI						
Underweight	2.71 (0.98, 7.49)	0.054	0.95 (0.43, 2.10)	0.903	1.71 (0.42, 6.90)	0.451
Normal weight	Ref.		Ref.		Ref.	
Overweight	**2.61 (1.56, 4.37)**	**<0.001**	**1.69 (1.26, 2.27)**	**0.001**	**2.08 (1.22, 3.52)**	**0.007**
Self-rated health						
Very poor/poor/fair	1.25 (0.75, 2.09)	0.391	**1.65 (1.24, 2.21)**	**0.001**	**2.05 (1.15, 3.67)**	**0.015**
Good/very good	Ref.		Ref.		Ref.	
Physical performance						
Gait speed	**0.14 (0.04, 0.49)**	**0.002**	**0.12 (0.05, 0.27)**	**<0.001**	**0.004 (0.001, 0.018)**	**<0.001**
Grip strength	**0.96 (0.92, 1.00)**	**0.046**	0.98 (0.94, 1.01)	0.147	0.96 (0.90, 1.02)	0.162
Environmental factors						
Concentration of $PM_{2.5}$	**1.13 (1.02, 1.26)**	**0.018**	0.98 (0.93, 1.04)	0.468	0.92 (0.83, 1.02)	0.132

Odds ratios in bold indicate statistical significance ($p < 0.05$). MMSE, Mini-Mental State Examination; GDS, Geriatric Depression Scale; PASE, Physical Activity Scale for the Elderly. The bold values indicate that the odds ratios are statistically significant (p<0.05).

having diabetes mellitus, arthritis, and osteoporosis were also associated with being rapid decliners in older women.

Discussion

The current study using a community cohort of older people in Hong Kong has identified two distinct IADL trajectories and three IADL trajectories for older men and women, respectively. Sex difference was observed in the patterns of IADL trajectories, but IADL functions in both men and women decline over time at an accelerated rate, suggesting that IADL function of older people in general declines with increasing age. Therefore, the factors found to be associated with the less favorable trajectories of IADL impairments in the further analyses could provide insights for identifying people who tend to decline rapidly.

Our results showed that older women tended to experience earlier and more severe IADL decline over time than men. A larger proportion of men maintained intact IADL at baseline while most women were already impaired in IADL function at their early 70s, as intermediate and rapid decliners. A previous study also found that there were more middle-aged women than men in the group of early onset of functional impairments [12], suggesting that IADL impairment among women perhaps start earlier in middle age or even younger age. Another distinct sex difference in IADL trajectories is that almost half of older women were identified as intermediate decliners who experienced progressive decline in IADL function over time. Together with those who were rapid decliners, a substantially greater number of women than men were living with declining IADL function as they aged. This can be explained by the sex differences in chronic conditions and muscle function. As compared to older men, women in the current study reported more chronic conditions that are debilitating and cause suffering, such as arthritis, osteoporosis, and cognitive decline. Furthermore, older women experienced faster decline than men in muscle function [13], which in turn may lead to greater decline in IADL function in women than in men.

Among factors associated with the IADL decline trajectories, being overweight or obese and slow walking speed were two robust predictors of more rapid IADL decline in both men and women. As people age, the higher level of BMI can be attributed to the increase in fat mass, decline in muscle mass, and/or increase in accumulation of fat inside skeletal muscle [14]. These changes in body composition or fat distribution can lead to the loss of muscle strength, and dispose older adults to higher risk of adverse health outcomes, such as sarcopenia, falls, and fracture [15]. Considering slow walking speed was also associated with the worse IADL trajectories, our findings underscore the importance of preserving muscle mass and muscle strength in the process of ageing.

Sex difference was also observed in the factors associated with the declining IADL trajectories. In older men, higher $PM_{2.5}$ was associated with higher risk of rapid decline, which was not seen in women, despite that the concentration of $PM_{2.5}$ in their residential area was comparable to that in men's. A recent study also found that the increases in disability and mortality from ambient PM air pollution were higher in men than women [16]. This sex difference could be partly explained by that men spent more time outdoors than women. We did not have direct measure of the time spent outdoors, but men reported significantly more leisure activities, suggesting that they could had greater $PM_{2.5}$ exposure outdoor. In contrast, poor self-rated health was associated with the more rapid declining trajectories in women but not in men. Self-reported health reflects the physical and psychological health status from the perspective of the individual, so the greater disease burden and inactive lifestyle in women may lead to their disproportionately poorer self-reported health.

This study was based on data collected from a large cohort of older community-dwelling people with an extended follow-up period of 14 years. To our knowledge, this is the first study to investigate the sex difference of IADL declining trajectories in an Asian population. However, there are some limitations to be considered. Individuals being excluded from analyses due to loss of follow-up were relatively older and less healthy than those who have attended follow-up visits (online suppl. Table 1; for all online suppl. material, see https://doi.org/10.1159/000543378). Consequently, the percentage of participants with less impaired trajectories might be overestimated. Furthermore, the duration between each follow-up was wide so some of the transitions could have been possibly missed. Time-varying variables should be considered in future studies.

In conclusion, this study has identified sex differences in the IADL decline trajectories and the factors associated with these trajectories. Being overweight or obese and slow walking speed were the robust predictors of rapid declining trajectories among both men and women. Having stroke, weak grip strength, and higher level of $PM_{2.5}$ were associated with the higher risk of rapid IADL decline in men while having osteoporosis and poor self-rated health were associated with more rapid declining trajectories in women. Our findings suggested that sex differences should be considered when designing interventions to prevent functional impairments in an earlier stage.

Acknowledgments

We are grateful the generous donation of Ms. Therese Pei Fong Chow. We thank all the participants and research team members in Jockey Club Centre for Osteoporosis Care and Control for their contribution to this study.

Statement of Ethics

The study was approved by the joint Chinese University of Hong Kong and New Territories East Cluster Clinical Research Ethics Committees in Hong Kong (Reference number [2003.102]). Written informed consents were obtained from all participants.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

This study was supported by the National Institutes of Health (AR049439- 01A1).

Author Contributions

Zhihui Lu: conceptualization, methodology, formal analysis, investigation, and writing – original draft. Jason Leung: data curation, formal analysis, and writing – review and editing. TW Auyeung.: conceptualization and writing – review and editing. Jenny Lee, Kenneth Lo, King-Son Lai, and Kuen Lam: writing – review and editing. Jean Woo and Timothy Kwok: conceptualization, funding acquisition, methodology, supervision, and writing – review and editing. All authors approved the final version of the manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this article and its supplementary material files. Further inquiries can be directed to the corresponding author.

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