The Bidirectional Relationship Between Cognitive Function and Loss Hierarchy of Activities of Daily Living Among Older Adults with Disabilities in China: A Cross-Lagged Analysis

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Abstract

Background

The Chinese population is experiencing rapid aging, limitations in activities of daily living and decline in cognitive function among the oldest-old group causes tremendous economic, family and social burden. Examining their relationship is critically relevant for policymakers. The present study aimed to determine the bidirectional relationship between cognitive function and the loss hierarchy of activities of daily living among older adults in China.

Methods

Data were derived from a sample of 469 older adults who participated in both the 2010 and 2013 waves of a Longitudinal Study on Family Caregivers for Frail Older Adults. Cognitive function was assessed using the Chinese version of the Short Portable Mental Status Questionnaire and activities of daily living were measured by self-reports of having difficulty or needing help with basic daily activities. A cross-lagged analysis was adopted.

Results

In general, the results showed cognitive function in 2010 was a significant predictor of middle loss activities of daily living (dressing, moving, bathing and toileting) in 2013, and late loss activities of daily living (feeding and hygiene) in 2013. The loss hierarchy of activities of daily living among older adults was not shown to be significant as a risk factor of cognitive function in 2013.

Conclusions

The findings expanded understanding of the relationship between cognitive function and the loss hierarchy of activities of daily living as well as provided evidence for clinicians and service planners for anticipating the subsequent care and service needs of the elderly and their families.

Background

Global population aging has made it necessary for health and social systems to further enhance quality of life by adding healthy years to people's lives. However, the prevalence of age-related health problems is becoming an important public health concern together with the population aging. One of the most important health care issues facing today's elderly population is cognitive impairment and its implications [1]. Cognitive impairment is a complex syndrome that would undermine activities of daily living and quality of life [2]. Indeed, the prevalence of disability in basic activities of daily living (ADLs), such as feeding, dressing, and bathing, increases with advancing age as well [3]. In 2018, the World Health Organization proposed to build a supportive environment to prevent decline in physical and cognitive function of the elderly and to further

enhance the quality of their prolonged lives. Hence, understanding the factors that influence ADL disability and cognitive functions of older adults will contribute to future social policy and long-term care service planning.

An increasing number of studies indicated the relationship between cognitive function and ADL disability is complex and potentially bidirectional. On one hand, there were research findings suggest that cognitive dysfunction is a major risk factor associated with ADL disability [4-7]. On the other hand, it was observed that older individuals with activities of daily living (ADL) limitations were more likely to be diagnosed with dementia [7-9]. A meta-analysis indicated that it could be possible that ADL disability and changes in cognitive function may, in part, share a common pathological basis [10]. However, previous studies have largely overlooked the bidirectional relationship of cognitive function and ADL disability. Thus, examining the bidirectional relationship between cognitive function and late-life disability in basic ADLs would contribute to the further delineating of their relationship. Furthermore, in literature testing relationship between cognition function and ADL disability, no study has taken into consideration of ADL hierarchy. This is not only a methodological limitation, but a theoretical limitation as the change of activities of daily living is hierarchical instead of continuous. If it was treated as a continuous, researchers would be likely to attain the weakened consequences. Therefore, this study aimed to provide clearer clues on the relationship between the elderly's cognitive function and the loss hierarchy of activities of daily living, which may expand the accumulated knowledge and help professionals determine future healthcare needs.

The influence of cognitive function on ADL disability

Findings from cross-sectional studies across samples of older people with and without dementia have shown the association between the decline of cognitive function and ADL disability [4, 5]. Especially in the middle and later dementia stages, the association between cognitive function and functional ability in ADLs becomes stronger [11].

Furthermore, results from longitudinal research have demonstrated that cognitive impairment may precede ADL disability among older individuals [12]. In a 52-month study of functional decline in nursing home residents, researchers found that severe dementia predicted poorer ADL functioning [6]. Similarly, in a community-based longitudinal study, the main findings demonstrated that cognitive score predicted subsequent ADL disability in both non-demented older adults and patients with Alzheimer's disease [13].

The biopsychosocial model of the disablement process (Verbrugge & Jette, 1994) may help to describe how cognition impairment leads to ADL limitations. According to this model, ADL disability is hypothesized to be an outcome based on physical and/or cognitive constraints as well as environmental barriers and/or psychological factors. For example, if elderly people are unable to bathe themselves independently (an ADL), it may be because of severe arthritis limiting hand movement (a physical impairment) or because of cognitive deficits restricting their ability to perform this task in sequence. Therefore, researchers suggested that regular screening of cognitive status is important to anticipate the potential onset of disability and delay this process where possible [4].

Although the cross-sectional studies mentioned above have shown that cognitive function is associated with older people's ADL function, and evidence from longitudinal research indicated that cognitive function was an important predictor of the elderly's subsequent limitations in ADLs, it remains unclear whether this holds true for different stages of the ADL function loss process. As demonstrated in many studies, there is a hierarchical structure to the loss of basic activities of daily living [14-16].

The effects of ADL disability on cognitive function

There are many cross-sectional studies observing the typical association of physical function and dementia that adopt ADL status as a diagnostic indicator of dementia. Specifically, older individuals with ADL limitations were more likely to be diagnosed with dementia [7-9].

Although longitudinal studies have provided some clues for understanding the dynamics of the relationship between physical and cognitive function of the elderly, there is a lack of detailed information on the effects of ADL disability on cognitive function among Chinese older adults. A few studies indicated that individuals without dementia or preclinical dementia were first experiencing frailty, such as gait and balance impairment, being underweight, and weaker grip strength [17, 18] or having limitations in the more complex instrumental activities of daily living (IADL) [19]. One possible explanation for this is that there is some specific pathology impacting physical function that exacerbates dementia progression. For instance, cognitive impairment may share neurologic pathology with physical performance tasks [20]. Only limited research found that ADL disability was a significant predictor of dementia onset, after controlling for baseline cognitive function [21].

The aforementioned findings have provided valuable clues for understanding how physical function relates to cognitive function among elder people. However, there is limited direct investigation examining the association between ADLs and cognitive impairment among older adults without dementia [22]. Although there were some studies indicating the association between IADLs (which require higher cognitive ability than ADLs) and cognitive impairment [10, 19], it could be possible that such relationship existed because essentially the pathology that eventually causes reduction in the cognitive abilities to complete IADLs may also cause the decline of cognitive status. A limited study which indicated that ADL was a risk predictor for dementia [21] failed to demonstrate whether different domains of ADL function loss carried comparable levels of risk to cognitive status because it only included ADL evaluations as a whole score in its research design. Thus, further studies need to be conducted to examine how changes in ADL loss predict cognition function. Demonstrating the relationship between cognitive function and changed need for ADL assistance is needed to help determine future healthcare needs.

Hierarchy in functional decline of ADLs

In order to capture the different domains of ADL function loss, previous studies have shown that the physical function loss of ADL was hierarchical in nature [14-16, 23] and can be formed as a pattern which would be helpful for monitoring ADL disability progression across episodes of care and predicting long-term care use among older adults who match the hierarchical loss pattern [15, 24, 25].

In some original research, it was indicated that among the ADL categories measured, participants on average lost the ability to bathe independently before losing their ability to dress, use the toilet, and transfer,

continence, and feeding [26]. In terms of older individuals with dementia, Giebel et al.'s 2015 study found that bathing and dressing impairments were present in earlier stages, whereas impairment in toileting, ambulation, and feeding was spared until the later stages [16]. Similarly, Fields et al. 2010 study indicated that when using a caregiver-report measure, problems in bathing and grooming appeared first, whereas eating was the last to be affected [14]. Comparative analysis was also conducted to examine the ADL loss hierarchy among older Americans and Chinese, which identified that that bathing is the first activity that both older Americans and Chinese have difficulty with, while eating is the last activity. There are differences in the rank order for toileting (ranked more challenging in the Chinese sample) and dressing (ranked more challenging in the U.S. sample) [15]. However, in some medical studies, a common conclusion has been reached that older adults tend to lose ability in activities that require lower extremity strength (e.g., walking) earlier than activities that require upper extremity strength (e.g., eating) [27, 28].

Although the reviewed literature indicated that the loss of ability to perform activities of daily living tasks demonstrated hierarchical structures, the hierarchy in functional decline demonstrated mixed patterns across societies due to the different populations studied and different measurement adopted. Researchers had highlighted potential impacts of demographic factors and subpopulations on the changes of ADL function [29]. For instance, the loss of activities of daily living was assumed to demonstrated different patterns between the oldest-old group (above 80 years) and other older age groups (60-79 years) [3]. Given the facts that the Chinese population is experiencing rapid aging, ADL disability among the oldest-old group causes tremendous economic, family and social burden, information on the loss hierarchy in basic ADL disability and its relationship with cognitive function is critically relevant for policymakers. Therefore, in order to provide more appropriate evidence on context-sensitive policy and service design, there is a need to explore the ADL loss hierarchy among older adults especially among the oldest-old in Chinese communities.

Based on this overview, three research gaps were identified: (a) the stability of the relationship between cognitive function and ADL disability over time has not been ascertained, although there is general consensus that the loss of ADL is a process and demonstrated as hierarchical structure; (b) no research has explored the bidirectional relationship between ADL changes and measurable cognitive changes although previous research has shown that decline in ADL functions and cognitive functions are interrelated and influence one another; (c) no local evidences have existed by exploring the relationship between the hierarchy of ADL function loss and cognitive function among Chinese older adults, especially the oldest-old who have more daily caring needs.

The present study tried to fill the identified research gaps highlighted above by determining the bidirectional relationship between cognitive function and the loss hierarchy of ADLs among older adults aged 75 above in China. By examining the bidirectional relationships between cognitive function and the loss hierarchy of ADL, the cognitive status of the baseline would be controlled, therefore providing clearer clues for understanding the stability of the relationship between cognitive functions and ADL disability over time. Moreover, by taking the structure of ADL loss hierarchy into consideration, it would help us to better understand the role that cognitive function may play in the stages of the ADL loss process. This would be useful at a practice level by determining eligibility for care services and predicting long-term care use among older adults.

Methods

Participants

Data were derived from the Longitudinal Study on Family Caregivers for Frail Older Adults Aged 75 or Above. The baseline study of this longitudinal research project was conducted in 2010, and follow-up surveys were completed in 2013 and 2016.

Quota sampling was adopted to recruit community-dwelling older adults and their primary caregivers. The sampling procedures consisted of two steps. First, one street office from each of the six urban districts in Shanghai was randomly selected. Second, 120 older adult–caregiver dyads from each of the selected street offices were recruited. The inclusion criteria for the older adults were as follows: (a) have a Shanghai urban household registration status, (b) be 75 years old or older, (c) have no fewer than two limitations in ADLs or equivalent, and (d) have one primary caregiver aged 18 years or older. To identify older adults with dementia, the Short Portal Mental Status Questionnaire (SPMSQ) was used [30]. Proxies were invited to answer the questionnaires for older adults whose educational attainment was less than high school level with an SPMSQ score higher than four and those who received college education or higher with an SPMSQ score higher than three.

Eligible older adult–caregiver dyads (n = 720) participated in the survey at baseline. Due to mortality-caused sample attrition, 487 and 374 of the original respondents completed the interviews in the 2013 and 2016 waves, respectively. New eligible respondents joined in both the 2013 and 2016 waves of the survey, generating working samples of 823 in 2013 and 733 in 2016. Older adults who successfully completed the 2010 and 2013 follow-up surveys (n = 468) were included in the data analysis.

Measurement

ADL disability was measured by self-reports of having difficulty or needing help with basic daily activities [31]. The respondents were asked: “Did you need help with the following basic daily activities in the past three months?” where these activities referred to walking, climbing stairs, feeding, dressing, hygiene, moving in and out of bed, bathing, and using the toilet. The responses were assessed by a 3-point Likert scale (0 = very difficult and fail to complete the task independently; 5 = difficult and need others’ assistance or using external devices; 10 = no difficult and can complete the task independently). Lower ADL scores indicated more functional limitations in the respondents’ daily lives [29]. The reliability coefficient of these eight items in terms of Cronbach’s alpha is 0.83, indicating good consistency and reliability. Cognitive function was assessed using the Chinese version of the Short Portable Mental Status Questionnaire [30]. The 10-item scale includes orientation, remote memory, personal history, and calculation (Cronbach’s α = 0.83). The responses were assessed by a binary variable (0 = correct; 1 = incorrect). Summed scores were calculated to represent the cognitive levels of the respondents (range = 0–10).

Statistics analysis

Analysis proceeded in two steps. In the first analysis, the objective was to investigate the structure that would present early, middle, and late loss of ADL function. We followed the approach proposed by Katz and his

colleagues [23] to explore the ADL loss hierarchy. The basic structure was attained by examining which ADL function remained independent longest as the older adults became less and less likely to maintain independence in any other areas of ADL function.

Second, a two-wave cross-lagged model was conducted to investigate the bidirectional relationship between cognitive function and the hierarchy of ADL loss. The cross-lagged analysis proceeded as follows. Firstly, measurement models of the hierarchy of ADL loss in the 2010 wave and the 2013 wave were built separately through confirmatory factor analysis (CFA) [32]. Then, the factor loadings of the latent constructs from the 2010 and 2013 waves were held equal to ensure that they represented the same latent construct across the two waves. Lastly, bidirectional causality between cognition and the hierarchy of ADL function loss was examined using the two-wave cross-lagged model. Variables of socio-demographic characteristics of the older adults (age, gender, and marital status) at the baseline were controlled.

All analyses were performed using *Mplus* 7 [33]. Maximum likelihood estimation was the default estimator. A series of fit indices were employed to indicate the model fit: the chi-square test, comparative fit index (CFI), Tuckere Lewis Index (TLI), root mean square error of approximation (RMSEA), and standardized root-mean-square residual (SRMR) [32].

Results

Demographic characteristics of the study sample

Demographic profiles of the study sample are shown in Table 1. As at the 2010 baseline, the average age of subjects is 82.1. The majority of the older participants were female (62.5%) and married (53.7%). The mean scores of their cognition function were 2.3 (SD = 2.1) in 2010 and 3.1 (SD = 2.2) in 2013, respectively. The mean ADL scores in 2010 and 2013 were 79.8 (SD = 15.4) and 73.6 (SD = 20.1), respectively.

Table 1
Demographic characteristics of the study sample (*N* = 469)

	N (%)	Mean (SD)
Age in 2010		82.1 (4.6)
Gender		
Female	293 (62.5)	
Marital status in 2010		
Married	252 (53.7)	
Other marital status	217 (46.3)	
Cognition Status		2.3(2.1)
2010		3.2 (2.2)
2013		
Physical function status in 2010		79.8 (15.4)
Physical function status in 2013		73.6 (20.1)

[Insert Table 1 about here]

Hierarchical profile of ADL loss

This study tried to attain the basic structure of hierarchical function loss by examining which ADLs remained independent longest as the subjects became less and less likely to maintain any residual areas of functional independence. In Table 2, the column headings represent the count of the number from 0 to 7 of the eight ADL areas in which the older adults maintained independence. The rows represent each of the individual ADL items. The values in the cells represent the number and percentage of persons who remained independent in ADL under the condition that there were only the indicated number of total areas in which the participant was still independent.

Table 2
Hierarchical profile of the physical function loss

ADL area	Independent in: Only "independent (= 10)"								
	0 ADL	1 ADL	2 ADLs	3 ADLs	4 ADLs	5 ADLs	6 ADLs	7 ADLs	Total
Walking	1 (0.7%)	0 (0%)	2 (1.4%)	3 (2.0%)	3 (2.0%)	9 (6.1%)	30 (20.4%)	99 (67.3%)	147
Stairclimbing	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (3.0%)	0 (0%)	12 (36.4%)	20 (60.6%)	33
Feeding	5 (1.3%)	6 (1.6%)	20 (5.2%)	34 (8.8%)	54 (14.0%)	58 (15.0%)	83 (21.5%)	126 (32.6%)	386
Dressing	0 (0%)	3 (1.0%)	2 (0.7%)	12 (4.0%)	33 (11.0%)	47 (15.7%)	78 (26.1%)	124 (41.5%)	299
Hygiene	0 (0%)	5 (1.4%)	7 (2.0%)	27 (7.5%)	55 (15.4%)	56 (15.6%)	82 (22.9%)	126 (35.2%)	358
Moving	0 (0%)	1 (0.4%)	2 (0.8%)	10 (4.0%)	26 (10.4%)	33 (13.3%)	59 (23.7%)	118 (47.4%)	249
Bathing	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)	2 (2.6%)	4 (5.1%)	24 (30.8%)	47 (60.2%)	78
Toilet	0 (0%)	0 (0%)	2 (0.7%)	11 (3.6%)	35 (11.4%)	53 (17.3%)	80 (26.1%)	125 (40.8%)	306

From these analyses of the hierarchy of physical function loss, we conclude that there are two early loss ADLs (walking and stair climbing), four middle loss ADLs (dressing, moving, bathing, and toileting), and two late loss ADLs (feeding and hygiene).

[Insert Table 2 about here]

Cross-lagged model results

As demonstrated in Fig. 1, measurement models of the hierarchy of physical function loss during the 2010 and 2013 waves were established before testing the cross-lagged model. Confirmatory factor analysis was used to examine the relationships between the factor indicators and the corresponding factors, including factor loadings, factor variance, and correlations. Maximum likelihood estimation was the default estimation technique. The latent construct of the hierarchy of physical function loss had three factor indicators: early loss, middle loss, and late loss. To ensure that the two measurement models measured the same latent construct, the factor loadings of these three indicators were held equal across the two survey times. The model fit indices showed that the measurement models provided a good fit, $\chi2$ (85) = 107.12, $p = 0.05$, RMSEA = 0.02, CFI = 0.99, TLI = 0.99, SRMR = 0.04. The standardized factor loadings of the five factor indicators ranged from 0.46 to 0.95 and were all statistically significant at the 0.001 level.

[Insert Fig. 1 about here]

The results of the fit indices demonstrated adequate model fit for the cross-lagged model. $\chi 2$ (143) = 170.74, p = 0.06, RMSEA = 0.02, CFI = 0.99, TLI = 0.99, SRMR = 0.03. As demonstrated in Fig. 2, the cross-lagged model has shown that cognitive status in 2010 was a significant predictor of middle loss ADLs in 2013 [β = -0.13, p < .05], and late loss ADLs in 2013 [β = -0.17, p < .01]. The hierarchy of physical function loss among frail older adults was not verified as a risk factor of cognitive status in 2013.

[Insert Fig. 2 about here]

Discussion

This study is among the first to present local evidence on the bidirectional relationship between cognitive function and the hierarchy of ADL loss among Chinese older adults. The integrated model of cognition and ADL loss hierarchy proposed by this research indicated that the baseline cognitive status was a significant predictor of the follow-up middle (dressing, moving, bathing and toileting) and late loss ADLs (feeding and hygiene). Consistent with previous literature, the findings showed that the baseline cognitive status was significantly associated with subsequent ADL loss [6, 13]. However, it is worth stressing that this study made new contributions by simultaneously testing the reversed relationship and found that such relationship was statistically non-significant when baseline cognitive status was controlled in the model.

Results did not provide evidence for the baseline ADL loss hierarchy affecting the subsequent cognition function of the elderly. Therefore, the bidirectional causality between cognition function and ADL disability failed to be verified. It appears likely that the middle and late loss ADLs are the direct result of cognitive impairment.

Our findings have also made contributions to the cumulative knowledge by stressing the influence of cognition function on ADLs holding stable within stages of the disability process. However, the findings showed that cognition function affects middle and late loss, rather than early loss. The potential explanations are as follows: this data consists of disabled older adults aged 75 years and older who had ADL scores equal to or lower than 90. It is important to note that early loss of ADL means ADL tasks that are lost during the first stage. Furthermore, cognition function is associated with age. The decline rates accelerate when older adults get older. In this case, it might mean that the majority of respondents would already have lost their walking/climbing stairs capacities when their cognitive functions start to decline.

The findings of the present study have the following service promotion and intervention implications. Firstly, the hierarchical loss pattern may have many applications, resulting in clinicians and social workers seeking less ambiguous guidance on what is happening to older adults. It would also help service planners anticipate caring needs of the elderly and their family members. Secondly, these findings have also shown the importance of monitoring change of cognitive function to anticipate the potential onset of disability and, where possible, delay this process by providing relating ADL function training service. Lastly, since cognitive status was a significant predictor of ADL loss, this indicated the necessity of developing interventions to simulate and maintain the elderly’s cognition status. Congruent services to provide education on nutrition

and encourage social participation of the elderly and their family caregivers would be developed in community-based environments.

Despite the merits of the present study, it has several limitations. Firstly, data from this study were collected from six urban communities in Shanghai, China. This may constrain the generalization of the proposed model and findings. Future studies may need to verify the model in other contexts. Secondly, this study did not include variables of continence and bladder function because the aim of this study was to provide suggestions about ADL that caregivers and service providers could help with. To date, previous studies examining ADL loss hierarchy also barely took bladder and continence into consideration [14–16]. Future studies may take these two activities into consideration according with different research objectives. Another limitation is that the assessment of older adults' cognitive function relied on SPMSQ. Future studies are needed to take closer look at dementia population.

Conclusion

In conclusion, by using a longitudinal data of individuals aged 75 years above, this study fills the research gaps by describing the hierarchical loss patterns of ADL among oldest-old adults in Chinese communities and demonstrating the cognitive function was a significant predictor of middle and late loss hierarchy of activities of daily living. With an unprecedented and pervasive process of aging, this specific age group is at greater risk of unmet caring and medical needs due to the challenges they face in cognitive and physical function loss, their reliance of other for support and the barriers they face in maintaining community integration. Thus, evidences provided in the present study could potentially improve the quality of life of these persons and their caregivers and could play an important part in the health care planning process.

Abbreviations

ADL
Activities of Daily Living
IADL
Instrumental Activities of Daily Living
SPMSQ
Short Portal Mental Status Questionnaire
CFA
Confirmatory Factor Analysis
CFI
Comparative Fit Index
TLI
Tuckere Lewis Index
RMSEA
Root Mean Square Error of Approximation
SRMR
Standardized Root-mean-square Residual (SRMR)

Declarations

Ethics approval and consent to participate:

This research submitted study-related materials for ethical clearance and was approved by the University of Hong Kong Human Research Ethics Committee (Institutional Review Broad protocol number: EA030313). Prior written consent forms were all obtained before participants were asked to fill out the questionnaires. As the primary caregivers of the elderly with cognitive decline also provided consent. The informed consent form mainly covered the following information: purposes and objectives of the study, importance of the study, principle of voluntariness, principle of confidentiality, and information about the contact person etc. The participants were entitled to terminate the survey at any time.

Consent for publication:

Not applicable

Availability of data and materials:

The dataset analysed during the current study is available from the corresponding author on reasonable request.

Competing interests:

The authors declared no potential competing interest with respect to the research, authorship, and/or publication of this article.

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Authors' contributions:

QS contributed to interpretation of the findings, drafting of manuscript, and revision of manuscript. NJ contributed to the interpretation of the findings, and revision of manuscript. NL contributed to the data cleaning, data analysis, and revision of manuscript. VWQL contributed to the study design, data collection, interpretation of the findings, and revision of manuscript. All authors read and approved the final manuscript.

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Figures

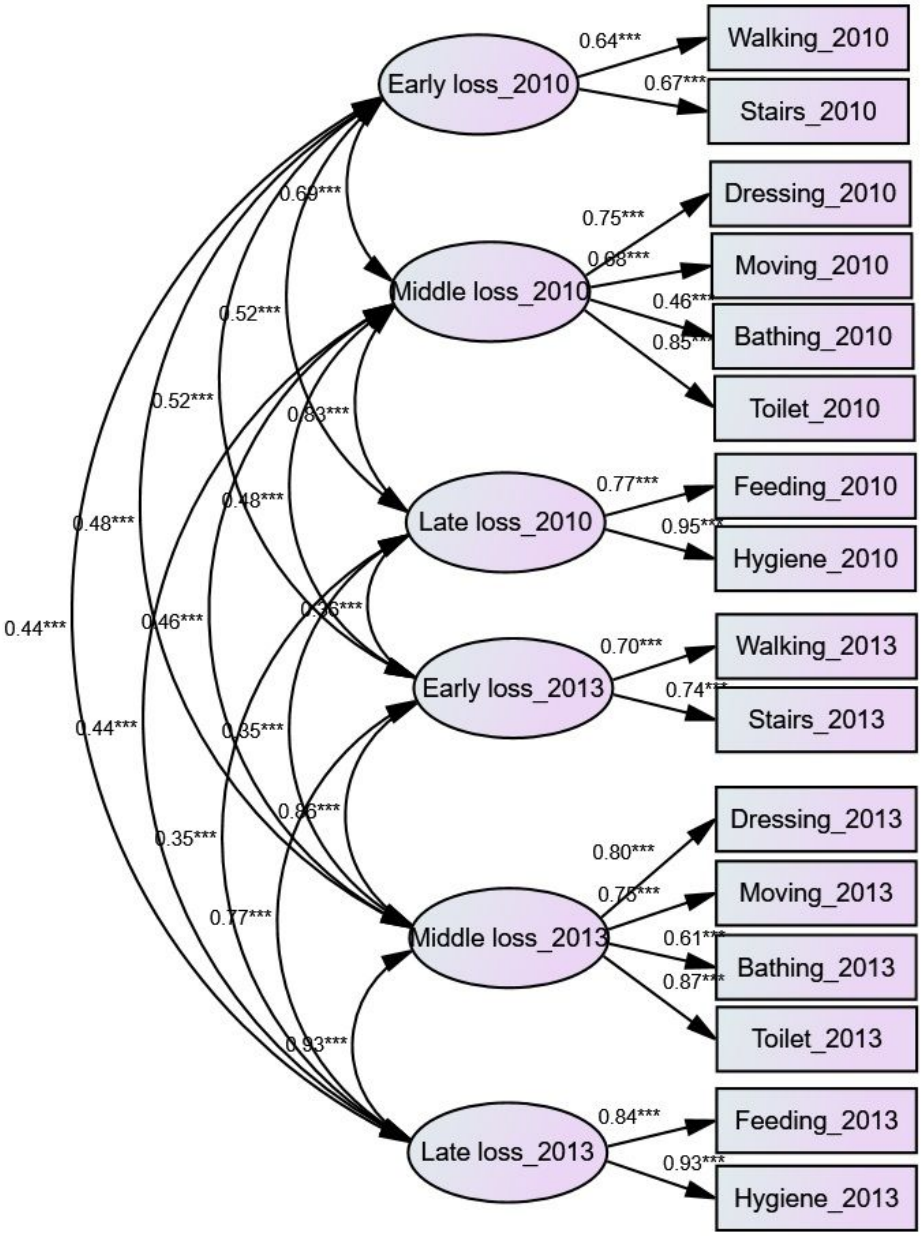

Figure 1

Measurement model of hierarchy physical function loss *p < .05 (two-tailed); **p < .01 (two-tailed); ***p < .001 (two-tailed).

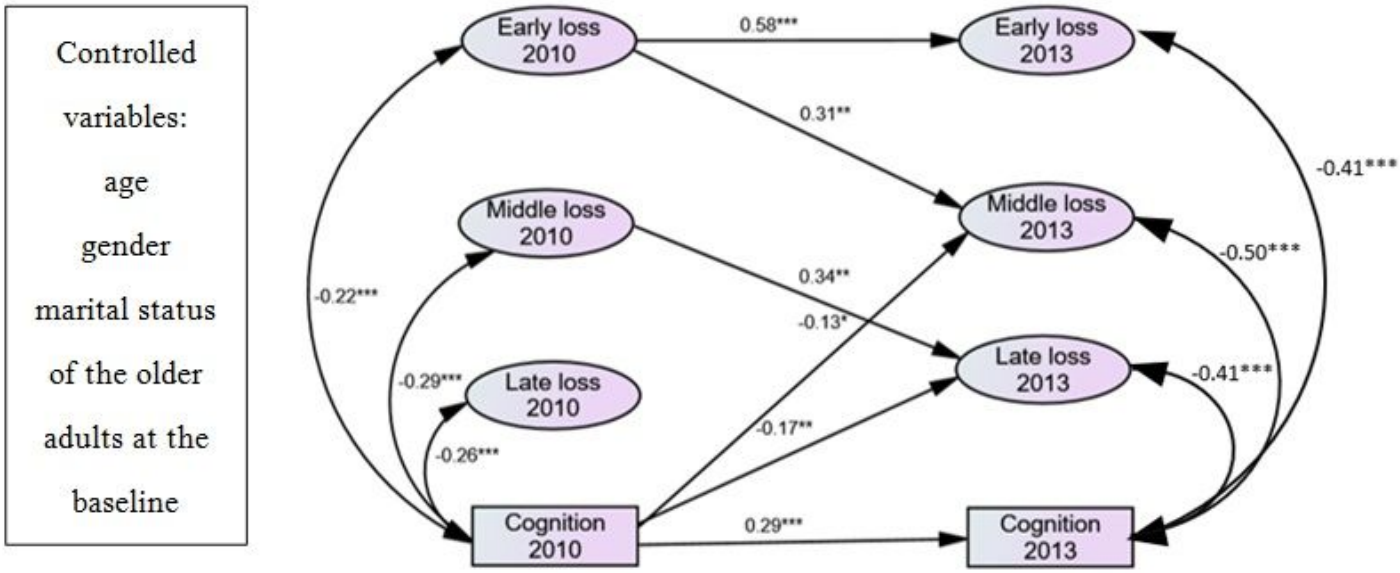

Figure 2

Cross-lagged model *p < .05 (two-tailed); **p < .01 (two-tailed); ***p < .001 (two-tailed).