

# Progression of Physical Function Decline and Gender Difference Among the Elderly in China: A Multiple-Group Latent Transition Analysis

Shuai Fang (✉ [3283263009@qq.com](mailto:3283263009@qq.com))  
Shanghai Academy of Social Sciences

---

## Research article

**Keywords:** physical function, aging, health states, latent transition analysis, gender inequity

**Posted Date:** November 20th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-107335/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

---

## Abstract

**Background:** Previous research has shown the physiological basis and empirical evidence for judging representative functional statuses and the functional decline pattern characterized by the specific combination and coevolution of multi-limitations among the elderly. However, as for health measures, under the conventional variable-centered view, studies mostly outlined physical function conditions by quantized severity levels rather than the qualitative profile and possessed the status change just uptrend or downside. This paper's central issue is to identify the constructed latent status of physical function among the Chinese elderly, explore the law of the coexistence and progress of functional limitations, also refine the comprehension of gender inequality with age.

**Methods:** We selected 1578 valid elderly samples who participated in the Chinese Longitudinal Healthy Longevity Survey in 2002, 2008, and 2014, and undertook latent transition analysis to construct the latent status, conduct the membership change overtimes, and examine gender disparity by introducing the multiple-group latent model.

**Results:** Chinese elders could be divided into five typical physical functional latent statuses. Upper extremity mobility was a distinguishing factor with unimanual dexterity or grip strength. The functional decline started with highly strength-required actions, then, the risk of mobility dysfunction and unimanual inexterity released predominantly, accompanied by visual and hearing problems. Upper limb disorders rarely occurred alone. The gender differences in distribution and transition of functional status were both distinguishable ( $\Delta G^2=74.59, df=4, p<0.000$ ;  $\Delta G^2=110.86, df=40, p<0.000$ ). Male elderly preferred maintaining extreme states with a lower risk of deterioration and a higher chance of recovery; females tended toward an unhealthier state and sank into the middle state. Whether gender inequality within physical health expands or shrinks with aging was related closely to the initial status.

**Conclusion:** This study bridges the gap between individualized studies and health measures by typology reference, differentiating the key functional stage and persons at risk. Medical treatments could prioritize the upper limb mobility secure and the strength enhance. Health equity promotion should consider gender typing and original status. Further, individual behaviors under diverse health types would be compared to demonstrate the heterogeneity in real needs and formulate targeted health interventions.

## Background

Physical functional limitations are restrictions in performing fundamental body actions such as overall mobility, discrete motions, strengths, watching, and listening (Verbrugge and Jette, 1994). They were considered the symptoms or functional consequences of single events such as disease and injury or attributed to aging directly and inevitably (Tuna et al., 2009). Multiple functional limitations often occur cooperatively among the elders, leading to a superposition and synergistic effect in health damage (Guralnik et al., 1995; Campbell et al., 1994; Bonsdorff and Rantanen, 2011). For example, visual and hearing disorders coexist commonly, increasing the risk of other difficulties, like mobility decline and upper limb restriction (Viljanen et al., 2012); lower-extremity strength appears to lose before upper-extremity strength for the elderly (Jagger et al., 2001).

Illuminating researches have drawn into the field of disability. The hierarchical structure in ADLs and IADLs were discussed much (Kempen et al., 1995; Andrew et al., 2012). Accordingly, Ferrucci et al. (1998) identified five activity fields of progressively disabling levels among the elderly, then utilized a theoretical model of functional deterioration based on patterns of the impairment on balance, lower extremity strength, gait, manual dexterity, upper extremity strength to verify the hierarchical order of disability, and concluded the disabling process followed a general pattern of progression based on a typical sequence of impairments.

Thus, as the direct manifestation of impairments, reasonably, it is believed that physical function status can be defined quintessentially, and its decline advanced gradually shaped by each given disparate types of coexistence and accumulation of diverse but interlinked underlying physical dysfunction. Slaug et al. (2016) just applied latent transition analysis to identify three groups of physical function: Mobility Problem Stayers, Hearing Problem Advancers, Visual Problem Advancer using five functional limitation category and stated that further decline was characterized by the addition of either visual problems or hearing problems, which were both associated with an increased risk of limitations in upper extremities.

The previous studies indeed provided physiological basis and classification evidence to realize the judge and explain the representative physical functional status characterized by a specific combination and coevolution of multi-limitations. Besides, with the expanding scope and structuration of well-being, identifying the profile of individuals' status such as Wolinsky's three-dimensional configuration (1980) and ICF (WHO, 2001), has been brought out, which indicates a new idea for assessing physical function. In China, the physical function has been extensively explored in clinical medicine or nested in disability study in sociology and demography. In either case, under the conventional variable-centered investigation by score or count of the scale (Xu et al., 2011; Qiu et al., 2017; Zeng et al., 2020), health stratification was outlined by quantized severity rather than qualitative traits. Such works ignored the correlation within dimensions or indicators and their role in the co-construction on each health status, and possessed the health status transition just uptrend or downside. Moreover, physiological factors have a real effect on physical function; gender heterogeneity in the life course is complicated and confused (Jiao, 2014; Zheng and Zen, 2016). It is meaningful and indispensable to examine further the existing interpretative and competitive theories from the new perspective of functional status distribution and transition trajectory.

This paper's central issue is to utilize latent transition analysis to structure the latent status, conduct the membership change overtimes, and examine gender disparity by introducing the group variable, to identify the typical physical function status of the Chinese elderly, explore the law of the coexistence and progress of functional limitations, and refine the comprehension of gender inequality with age. The significances achieved in this work are: in terms of methodology, to bridge the gap between individualized studies and health measure by typology reference, which is more conducive to grasp the abstract property of subgroups than taking index-quantitative level as a criterion; theoretically, deeply into variables mining, to establish a finite and specific

correlation among functional components, rewarding to proof and develop the rationale of the formation and progress of functional limitations; as for the practical sense, to refine the comprehension of health states change rules of the aging in China.

## Methods

**Aim and Design** Firstly, we proposed typical functional status featured by the particular performance of multi-limits coexistence and accumulation to subdivide the elderly. Then, each status's prevalence and transition probabilities were computed to probe into the relationships within each physical functioning and its development. Lastly, health disparity between genders over time was ulteriorly demonstrated in a distinctive angle of the old folks' classification and physical status transfer.

**Data and sampling** Data were from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), a national longitudinal survey compiling extensive data including physical function on a large population of the oldest-old aged 80–112 elders aged 65–79 since 1998. The survey is conducted on a selected sample from 23 out of 32 provinces in China. The covered area population reached 1.16 billion in 2010, accounting for 85% of the national population. In this work, the elderly participated in all surveys of 2002, 2008, 2014 were selected; there were 1578 valid samples without missing and logically incorrect data. There were 829 women and 749 men. 12.8% of participants were aged 80 and over.

**Manifest indicators of physical function and grouping variable** Physical function are tested clinically by the index of muscle tone, range of joint activity, gait, balance and coordination, sensory and cardiopulmonary function (Liu et al., 2014). Functional limitations are manifested by implementing core activities of daily life, such as walking and moving, carrying and lifting, viewing, and listening (Verbrugge and Jette, 1994). This study mainly focused on the performance of essential physical function (Wu and Xu, 2004) and selected 11 indicators from three dimensions to construct the elderly's physical function state: (a) vision function: see and distinguish the break in the circle and the direction of the gap on the cardboard sheet; (b) hearing function: hear the questions without hearing aid; (c) limb function: both hands behind the neck, both hands behind the lower back, raise arms upright, lift a weight of 5 kg, crouch and stand up three times, walk continuously for 1 km, pick up a book from the floor by standing, sit to stand without using hands, turn around within ten steps. We recoded the categories variables into a binary outcome: 2 for response 'can, without help' (unlimited), and 1 for other answers (limited). Gender (male = 1, female = 2) was grouping variables in multi-groups latent transition analysis.

**Models and Processes** We used latent transition models (LTM) by SAS9.4 software PROC LTA to estimated parameters by the maximum likelihood of the Expectation Maximum algorithm and Newton-Raphson (Collins and Lanza, 2010). General LTM revealed the typical functional state of the elderly, and the proportion of each state tracked the membership change over time. Multiple-group LTM was used to test gender inequivalent on the distribution and transformation of functional state among Chinese elders. The latent status analysis identified latent statuses of physical function by response patterns of elderly on 11 observed indicators, divided individuals into distinct subgroups, and calculated latent status prevalences at baseline survey. Then we gained the latent status prevalences at multiple time points and transition probabilities of the elderly from one status to another within the longitudinal time intervals through transformation matrixes established by a hidden Markov process. Before modeling, Harman's One-factor Test was used to examine the common method biases of the sample. The first common factor variance contribution rates were 28.84%, 31.04%, 29.22% at three-time points, all below the critical value of 40%. This inferred that common attributes of each functional status rather than the certain self-reported bias, environment, context, or the project itself, determined the elderly's response pattern.

**Model fit and model selection** As an exploratory analytical approach, we used the Bayesian information criterion (Schwartz, 1978) and Akaike information criterion (Akaike, 1973) to choose the optimal number of latent statuses, the smaller which were, the better competing LTM fitted. There might be complex situations that each criterion did not identify the consistent model as optimal. Parsimony and explicable of latent status were two primary principles to choose a single best model. This study computed models with 2–7 latent status preset through PROC LTA syntaxes.

**Hypothesis test of measurement invariance** LTMs is generally premised on measurement invariance hypothesis to avoid excess and confusing latent status with inconsistent meaning across times and groups created by additional information derived from multiple measurements. Thus, latent status change can be measured straightforwardly, and group equivalence tests make the most sense. The hypothesis is tested statistically by comparing two LTMs, one with item-response probabilities constrained into parallel parameters by defining equivalence sets, another with them varied across times or groups. In this study, the difference  $G^2$  test provided a formal test of the null hypothesis that these two models fitted equally well; the better model was with lower AIC and BIC values. In practice, particularly in multiple-group LTM, even statistically significant, it is indispensable to make an ultimate judgment after combining research background and theoretical knowledge. In this paper, we further conducted the heterogeneous unrestricted model with entirely unfixed response probabilities. If latent statuses of each elderly subgroup were still basically consistent in structure and connotation, we assumed measurement equivalence confidently and believed the discrepancy of type partition on the physical function in distinct groups did not considerably impact model fitting and interpretation conceptually.

**Hypothesis test of gender differences in status distribution and transformation** If latent status prevalence at start time and transition probability are equivalent, we deem that no gender differences in the whole distribution and change of physical function status. This paper compared the model with latent status prevalences in 2002 and transition probabilities all fixed to the model with only latent status prevalence in 2002 constrained for testing gender differences of distribution, and to the one where only transition probabilities equaled for testing gender differences of transformation. Group differences were examd as the same strategy to compare nested models fit by difference  $G^2$  test and information criteria.

## Results

**Descriptive physical function characteristics of the study sample** Physical function was declining with age. Statistical description showed that the sample's proportion without function limits decreased from 64.70% in 2002 to 24.74% in 2014 (Table 1). Specifically, crouching and standing up for the elderly in China was the most arduous, followed by the outdoor walk and weight-bearing. Furthermore, the declining trend of visual function was evident with age; the completion and function decline on the actions as sitting to standing, picking up objects, and turning around were at a moderate level; general upper limb control was better and more stable. As for gender, female elderly were in more inferior function; explicit discrepancies were always observed in crouching and standing up, walking outdoors, carrying weights and vision, and gradually distinct in other functional indicators with age.

**Item-response probabilities and latent statuses of physical function of the elderly** Of the general LTA models with 2–7 latent statuses, a five-status model had the best fit in terms of the BIC and the principle of parsimony (i.e., BIC values were 11831.06, 10238.15, 9480.25, 9212.08, 9227.74, 9390.09 for models with 2,3,4,5,6,7 statuses, respectively). The five statuses could be interpreted meaningfully and emerged with reasonable status membership probabilities (see Supplementary); no irrelevant outlier status appeared. The latent status of the Chinese elderly's physical function was stable across three times (i.e., BIC values were 9631.96, 9212.08 for models with unconstrained and constrained item-response probabilities;  $\Delta G^2 = 108.05$ ,  $df = 110$ ,  $p = 0.53$ ). Five latent statuses with corresponding item-response probabilities of "limited" were defined (Fig. 1):

**Latent status 1:** Completely Dysfunction. Characterized by more than 66% probabilities of limitations on almost all function indicators and a 54.32% risk of losing hearing, the elderly in this status were extremely poor in the strength, balance, gait, and flexibility of upper limbs with a high risk of visual impairment and moderate risk of hearing trouble.

**Latent status 2:** Health. Conversely, this latent status revealed no more than 10% risk of each function limit, where the elderly had intact physical function.

**Latent status 3:** Lower extremity Dysfunction. Old folks in this status hardly completed "Crouch and stand up three times", "Lift the weight of 5kg", "Walk continuously for 1km" - the three most difficult for the elderly (see Table 1), which requires highly for strength, mobility, and balance. "Pick up a book from the floor by standing" is a crucial indicator to enter this state (82.19%). Additionally, they were at the upper-middle risk of trouble in "Sit to stand" (67.19%), "Turn around ( $\leq 10$  steps)" (65.55%), and the increased rate of loss of vision and hearing (60.62%, 37.59%). These actions nearly involve lower extremities ability, and unimanual dexterity also loads much on body agility and single-leg balance by factor analysis (Greene et al., 1993).

**Latent status 4:** Limitation on High-intensity action. This status was featured by over 50% response probability for "limited" on three high-intensity actions as "Crouch and stand up three times" (64.64%), "Lift the weight of 5kg" (49.76%), "Walk continuously for 1km" (49.53%). The elderly in this status faced medium-low risk in visual (28.84%), and low possibility in other limits. This status reflected the low level of function deterioration.

**Latent status 5:** Upper limb Mobility Dysfunction. In utterly contrary to latent status 3, the elderly in this status could not complete "hands behind the neck", "hands behind the lower back", "raise arms upright" independently (90%), but performed well on strength/manipulating-required movements like carrying and picking up things, or other actions.

**Figure 1 Five latent statuses of physical function of the elderly in China** item-response probabilities of the response category as "unable to complete independently", constrained invariant across times; less 33% as low probability, 33–66% as medium probability, over 66% as high probability to define and describe each status clearly

**Distribution and transition of latent statuses of the elderly's physical function** Fig. 2 presented the change of latent status prevalences over three-time points. The latent status of *Health* was the most prevalent of the sample (78.52%, 63.47%, 38.01%), followed by *Limitation on High-intensity action* (15.61%, 23.90%, 33.35%). The elderly in the status of *Completely Dysfunction* (0.59%, 2.41%, 7.08%) and *Upper limb Mobility Dysfunction* (3.57%, 4.95%, 1.99%) were less common. With age, latent status prevalences of physical function changed much. The proportion of elderly in *Health* reduced by 50% from 2002 to 2014. Instead, the prevalence of *Limitation on High-intensity action* and *Lower extremity Dysfunction* were increased by about 18%. The prevalences of *Completely Dysfunction* were continuously up. Nevertheless, the latent status prevalence of *Upper limb Mobility Dysfunction* has slightly fluctuated.

The transition probabilities matrix of status membership in 2002–2008, 2008–2014 were displayed in Table 2. For the elderly in *Completely Dysfunction* in 2002, the physical function had an obvious uptrend with 57.06%, 35.73%, 7.21% chance of recovering to the status of *Lower extremity Dysfunction*, *Limitation on High-intensity action*, and *Health* at 2008. However, conditions became complex in the second time interval. With age, the elderly in the same state had improved retention rate (17.79%) and full recovery rate (14.71%), but a reduced chance to only high-intensity action limitation (16.01%). Nevertheless, *Lower extremity Dysfunction* was still the primary accepting state for the elderly in severe disability (51.49%).

The elderly in *Health*, *Limitation on High-intensity action*, and *Lower extremity Dysfunction* were more likely to retain original latent statuses than changing into another status, particularly ones in *Lower extremity Dysfunction*. Once the transition occurred, the elderly in *Lower extremity Dysfunction* were at the highest risk of deterioration (21.22%, 21.84%). With age, the stability of being *Lower extremity Dysfunction* enhanced (55.47–62.66%) with the corresponding reduced rate of full recovery (12.24–0.95%), while those of being the former two decreased (71.99–50.70%, 48.43–40.10%) and they were in the face of immediate increased risk of deterioration. For healthy older adults, the risk in limitation in the high-intensity movement was from 18.85–32.42%, in lower limb dysfunction were from 2.98–11.51%. Those just in high-intensity action restriction, the risk of losing lower limb function was from 10.55–30.06%, of total dysfunction from 6.02% to 12.73%.

The frequent interchanged happened between the latent status of *Health* and *Limitation on High-intensity action*. The latter was the primary direction to transfer for the healthy elderly, with a raised transition rate with age (18.85–32.42%). However, on the contrary, those just suffering in challenging actions had a decreased chance of full recovering (29.37–15.86%) and more easily worsened into *Lower extremity Dysfunction* (10.55–30.60%).

The latent status of *Upper limb Mobility Dysfunction* was unstable, and the elderly in this state were most likely to fully recover (59.10%, 33.22%) or get into trouble in high-intensity action (31.93%, 44.60%). With age, the recovery opportunity got much smaller; the worsening risk of *Lower extremity Dysfunction* (0.00–10.81%) and *Completely Dysfunction* (3.54–9.34%) got higher and higher.

**Figure 2 Latent status prevalences of physical function of the sample at 2002,2008,2014** item-response probabilities constrained invariant across times and gender groups

**Gender difference of distribution and transition of latent statuses of elderly physical function** Of the multiple-group LTA models with 2–7 latent statuses, a five-status model had the best fit in terms of the BIC and the principle of parsimony (i.e., BIC values were 12983.13, 11438.31, 10740.15, 10570.60, 11013.21, 11408.36, AIC values were 12824.75, 11132.11, 10243.89, 9842.06, 9693.38, 9718.98 for models with 2, 3, 4, 5, 6, 7 statuses, respectively). The heterogeneous unrestricted model demonstrated that the latent status composed by item-response probabilities was consistent in structure and connotation between male elderly and female elderly (see Supplementary). The five-status multiple-group LTA model with item-response probabilities gender-constrained had the extremely similar items-response probabilities to the general LTA model above. These suggested that the latent status of the Chinese elderly's physical function was stable; there was no difference in the elderly's division by physical functional state across gender. These five latent statuses "Completely Dysfunction", "Health", "Lower extremity Dysfunction", "Limitation on High-intensity action", "Upper limb Mobility Dysfunction" were typical.

The trend of latent status prevalences in each gender group was consistent with the overall sample. With age, the latent status prevalence of *Health* considerably decreased, but that of *Lower extremity Dysfunction* and *Limitation on High-intensity action* grew continually. The proportion of the elderly of *Completely Dysfunction* had a small rise, and which of *Upper limb Mobility Dysfunction* slightly fluctuated (Fig. 2).

Generally, the male elderly's physical function was better than that of the female, and the difference was significant ( $\Delta G^2 = 74.59$ ,  $df = 4$ ,  $p < 0.000$ ). Healthy elderly accounted for more in males (88.27%, 75.53%, 49.29%) than in females (69.06%, 52.25%, 27.21%), other latent status prevalences in men were lower than that in women universally. Also, the elderly's physical function declined more obviously in females. For female, the prevalence of *Lower extremity Dysfunction* sharply increased (2.36%, 8.35%, 26.39%), which of *limitation on High-intensity action* and *Completely Dysfunction* raised from 24.13–36.20%, from 0.68–8.04%; for male, the prevalence of *Limitation on High-intensity action* increased mostly (6.68%, 16.34%, 29.65%), which of *Lower extremity Dysfunction* and *Completely Dysfunction* raised from 1.12–13.10%, from 0.47–5.97%.

The gender differences in the latent status transition were distinguishable ( $\Delta G^2 = 110.86$ ,  $df = 40$ ,  $p < 0.000$ ). As a whole, the chance of recovery of both genders reduced, and the risk of function deterioration was up, resulting in the change of latent status prevalences over three-time points. As Table 2 presented, for the elderly in the latent status of *Complete Dysfunction*, both genders' physical function tended to improve in the first time interval, with over 55% chance into *Lower extremity Dysfunction* and around 35% chance into *Limitation on High-intensity action*. With age, men got preferring keeping in *Complete Dysfunction* (0.06–25.99%) or recover fully (3.64–16.53%) than women (0.00–14.64%, 7.90–14.46%), and *limitation on High-intensity action* gradually became the main transition direction (39.97–39.88%) instead of *Lower extremity Dysfunction* (56.33–17.60%). However, females were still the most likely to develop towards *Lower extremity Dysfunction* with raising transition probabilities (57.82–70.90%), and their chance of recovering to *Limitation on High-intensity action* declined much by 34.28%.

The male invariably kept healthy more readily than females, and the advantage was expanding with age. During the two time intervals, the health retention rate reduced from 80.30–58.61% of males, from 62.12–39.45% of females. The disadvantage in function deterioration of older women was also enlarging. For healthy males, the risk of *Limitation on High-intensity action* grew from 1.26–5.39%, and from 8.38–16.24% for females. The risk of *Lower extremity Dysfunction* of females (5.39–16.24%) grew faster than the male (1.26–8.38%).

For the elderly in the latent status of *Lower extremity Dysfunction*, women's status stability was higher. Retention rate were 66.68% and 60.77% for females, 29.83% and 61.89% for males. At first, the male had a much higher chance of improvement, and the female had a higher risk of deterioration, but with age, this disparity got narrowed and presented a reversal trend. Male risk of exacerbation increased from 13.89–24.19%, the chance of full recovery dropped from 33.11% to zero, and that of being *Limitation on High-intensity action* declined from 23.17–6.37%. However, three changes above among females were from 24.19–19.85%, zero to 1.83%, and 9.13–14.2%.

For the elderly with high-intensity action limitations, no matter men or women were always most probably to maintain in the original state, but the rate of the men reduced much with age (50.55–36.63%), thus getting lower than that of females (46.66–40.77%). With age, females got fewer advantages to recover entirely from 30.80–13.91% than males (27.60–20.11%). Moreover, females always had a slightly higher rate of further deterioration than males.

For the elderly in *Upper limb Mobility Dysfunction*, men had a greater possibility of change and rehabilitation, but this advantage reduced apparently with decreasing chance of recovering and increasing the risk of turning to *Limitation on High-intensity action*. The transition probabilities to *Health* were from 69.87–49.42% for males, 35.75–30.43% for females. The ratio to *Limitation on High-intensity action* were from 22.27–37.77% of males, 49.02–40.40% of females. However, the female disadvantage of risking deeper dysfunction expanded. The transition probabilities to *Completely Dysfunction* raised from 3.20–9.86% (3.87–7.43% for males), to *Lower extremity Dysfunction* raised from zero to 14.57% (3.99–7.80% for males).

**Figure 3a** Illustration of probabilities for latent status transitions in the total sample over three points, T1–T3; status membership probabilities within boxes; **b** Illustration of probabilities for latent status transitions in the male sample over three points, T1–T3; status membership probabilities within boxes; **c** Illustration of probabilities for latent status transitions in the female sample over three points, T1–T3; status membership probabilities within boxes

## Discussion

Our results reveal five typical physical function statuses of the elderly: *Completely Dysfunction, Health, Lower extremity Dysfunction, Limitation on High-intensity action, and Upper limb Mobility Dysfunction*. The physical function of the elderly in China is declining with age without a doubt with pronounced decreased incidence of being intact, mostly increased risk of limitation on high-intensity actions followed by lower extremity dysfunction. Comparing to three classifications posed by Slaus et al. (2016), the difference of released latent statuses here mainly originated from the choice of functional indicators. Slaus's prior research applied configuration frequency analysis to cluster functional indexes from House Enable in five functional limitation categories (Slaus et al., 2011), as manifest variables for the subsequent LCA, making latent statuses more transparent and interpretable. Our work used elemental physical functional items, structural features of latent status could be identified detailedly through each indicator. In either study, visual and hearing problems were indicative of further decline.

It is noteworthy that the visual deterioration appeared and progressed intensively, accompanying the process from the early to middle stage of function decline, correspondingly, from the status of *Limitation on High-intensity action* to *Lower extremity Dysfunction*. Reduced vision is associated with more serious lower body limitations, which medicates the role of vision impairment and disability (Femia et al., 2001). The poor sight has also been identified conformably as one of the risk factors for fear of fall (Murphy et al., 2003; Martin et al., 2005), and positive relations between FOF and postural balance or gait performance were recognized (Vellas et al., 1997; Kressig et al., 2001; Viljanen et al., 2012). Relatively, the risk of hearing impairments among the Chinese elderly is smaller, contrary to some results using American data (Campbell et al., 1999; Dillon, 2010), and the risk increases smoothly over the whole progress of functional decline.

Muscular strength in both grip or leg is a significant contributing factor to construct functional capacity (Era,1990). Tasks loading on this factor are nonspecific concerning the effector used, and performances on strength tasks significantly correlate with speeded movement, mobility, and balance(Greene et al.,1993). The Chinese elderly's movement disorder starts with the crouching and standing up, lifting weights, and walking outdoors serially, which require highly of maximal force. Limitations on these three motions coexist to compose the symbolic status of preliminary functional deterioration.

As the functional impairment deepening, the risk of unimanual inexterity and gait dysfunction release predominantly. The inability to pick up objects on the floor by standing indicates entering the persistent and intractable intermediate status of functional decline. The status is where the complete disabled originated and, conversely, hardly pass over to full recovery. Of individuals in this status, the risk of visual and hearing impairment grew dramatically as well. Detailed gait dysfunction among the elderly may be potentially associated with deficits in neurological (sensory input, motor coordination), musculoskeletal (strength, stability), and even psychological (fear of falling) (Tinetti, 1986), which influences mobility and related balance. Body agility and single-leg balance loaded slightly on manual inexterity, and unimanual dexterity and mobility are just verified as distinct dimensions with strength (Greene et al.,1993).

In this work, general upper extremity mobility is a distinguishing factor with unimanual dexterity or grip strength. Those under *Upper limb Mobility Dysfunction* could not stretch or lift arms to touch neck and back but took the weight and pick up things nicely.

At a population level, decrements in functional ability progress from activities that require dynamic balance, agility, and muscular strength down to activities with only the upper extremities performed (Ferrucci et al., 1998). Our study proves this hypothetical hierarchic model within a longitudinal framework to some degree, like that the elderly in *Lower extremity Dysfunction* transfer into the status of *Completely Dysfunction*. Consequently, the elderly only in trouble of upper limb trouble rarely exist. The inability to carry, grip, and handle referring to the strength and balance compose latent status characteristics together with other limitations. The elderly only in restriction of upper limb mobility recover much easily. However, the ultimate latent status from our research can not prove the front-back intra-sequence of the limitations occurred in each field forcefully and precisely, like movements, vision, hearing, and gripping ability as Slaus's results, but our research believed that physical function declines accompanied by visual and hearing problems and the loss of upper limb function.

The physical function of elders generally presents an intractable trend of gradual decline over time. This decline might usually start early in life and progresses alongside the normal aging process (Bonsdorff and Rantanen, 2011). Ego depletion is an integral theory to explain the aging phenomenon, and humans always have a life limit (Baumeister et al.,1998). Nevertheless, our results reflected that the recovery of the elderly's physical function still existed, particularly in upper limb mobility and the preliminary stage of physical dysfunction when muscle mass and strength were lost. Medical resources can be preferentially put on these two aspects to improve the rehabilitation rate and treatment efficiency.

The physical function of the male is better than that of the female. The significant difference almost existed in the prevalence of each elemental functional limitation; besides, women were more likely to have vision impairments(Rubin, 1997; Resnikoff et al., 2004; Hayward et al., 2010). Male preferred maintaining in extreme states of physical function like complete dysfunction or complete health and were at low risk of deterioration and a high chance of recovering from the dynamic side. Females tended to sink into an intermediate health state from a better one with nearly quarter-risk of worsening; they might take a favorable turn, still hardly recovered perfectly, so they were used to being inferior. Previous papers stated that males kept longer in health, and disabled female elderly stayed twice as long in nursing as them (Zeng et al., 2004; Brown and Finkelstein, 2007; Huang and Wu, 2012). Research on self-rated health examed similarly that old females easily retained a 'poor' health state, accompanied by a modest ratio of deterioration, yet males were exacerbated as possibly as they were recovered (Peng et al., 2009).

A host of scholars attributed this disparity to death selection of gender (Nam et al., 1978; Johnson, 2000; Dupre et al., 2006). Men are at a relative survival disadvantage and high mortality with shorter life expectancy (Crimmins et al., 2019), possibly due to their more professional working environment filled with risk and incidence in fatal diseases. A comprehensive health class study released an apparent paradox that more men were in the youngest and

healthiest class, and women dominated in the oldest and sickest class (McClintock et al., 2016). Hence, the male survivors entering old age would be healthy and robust individuals; accordingly, living older men have an upraised opportunity to improve their physical function (Rogers, 2000; Huang and Wu, 2012). In addition to the inherent physiological variance, the cumulative effect of health inequality in gender influence females' inferiority (Wei and Wang, 2017). Originating from distinct roles in family and society, especially in education and marital status, profound unfairness on social resources availability and effectivity exists between genders, triggering a disadvantaged position in females' health conditions later (Wheaton and Crimmins, 2016). The government should make the contrapuntal policy in response to older women's demographic, social, economic, and health characteristics.

The aging trend of health inequality has always being a complicated problem and research focus (Zheng and Zen, 2016). Two competitive hypotheses—cumulative disadvantage and age neutralization effect were formed by introducing the view of life course into social stratification and inequality in health. A few studies stated that health inequality caused by education and residence expanded with age (Hu, 2014; Li and Zhang, 2014), but others held opposite opinions (Christenson and Johnson, 1995). More precisely, the inequality was extensive from youth and middle age to the early stage of old age, but tended to shrink or converge later (House et al., 1994; Kim and Durden, 2007). Other researches emphasized that gender inequality in specific health areas like depression symptoms had no suggestive change with age, but it was hardly judged to wide or narrow in self-rated health (Jiao, 2014).

Our study concludes whether gender inequality grew or shrunk with age are closely correlated to the initial health state. Firstly, among the elderly in the emergent period or extreme state of physical dysfunction, the cumulative advantage/disadvantage works, and female comparative disadvantage in keeping fit is expanding. The transition probabilities proposed the female in the latent statuses of *Limitation on High-intensity action*, and *Completely Dysfunction* held a faster-growing possibility of deterioration and reduced chance of preserving or recovering with age. In contrast, men had a positive trend to maintain in the states of intact or slight decline on physical function.

Secondly, among the elderly originated in the intractable middle state or unstable state of physical function, age neutralization effect plays a vital role. For the elderly in the latent status of *Lower extremity Dysfunction* or *Upper limb Mobility Dysfunction*, the male advantage of recovering and female disadvantage of health worsening were both diminishing with age. Two explanations give the background of the age neutralization effect. One is that biologically aging predicts individual health status more in the late of lifecycle comparing with other social and economic factors (House et al., 1994); another is selective death, that is, among the lower social class, ill individuals have died in the late middle age or early old age, leaving ones sturdy (Lynch et al., 2003). The first explanation mainly acts on the elderly suffering in upper limb mobility only, among whom both men and women had rising probabilities of health deterioration and falling opportunities of recovery, leading to the reduction of gender differences. The second explanation applies to the elderly in *Lower extremity Dysfunction*. Female elderly kept healthy hardly, vulnerable individuals of them died, strong ones survived. Consequently, they presented an increased chance of recovery and less descending during the second time interval, making gender disparity inapparent and even turning. The above condition also occurs in disabled elderly's self-care ability and healthy life expectancy (Hayward et al., 1998; Land, 2000).

However, for the elderly with physical function intact, the gender differences change little with age, neither reflecting cumulative effect nor age neutralization effect. While Zeng believed among the undisabled elderly, women had an expanding health disadvantage comparing to men with age (Zeng et al., 2007).

Overall, from the new perspective of distribution and transformation of physical function state, the aging phenomenon is ineluctable and dominant in physiology health, which produces a marked effect at the beginning of the functional decline. Once started, the proceeding is irreversible. As for health inequality during the life course, when the elderly are at the emergent or later period of the physical dysfunction, socioeconomic factors dominated, and the cumulative disadvantage leads to the broad gender disparity. Artificial intervention and economic support may bring more major utility to promote health and fairness among the elderly under these function states.

One major drawback of the approach is that data were from three-time nodes, not considering the annual change and complex situations. For individuals who had changed many times within the two periods, the explanation on status change was biased and rough. During data processing, this work also excluded the samples who dropped out, lost contact, and dead, considering the simplicity and low impact on classification results from extreme conditions or data missing. In the future, we would take more refined health dimensions like cognition as the latent variable into the comprehensive health status construction; it worth to attention to choose manifest indicators and name the latent status based on differentiation and medical professionalism. It is also looking forward to continuing to study health inequality besides gender disparity.

## Conclusion

Future research on comprehensive health status measures should focus on the unique nature of the different combinations of diverse dimensions of health status, rather than pursuing a single summary measure under the simple additivity and equality assumptions (Wolinsky and Zusman, 1980). This study's practical significance lies in developing assessment techniques from the typology method, which establishes the relationship among each functional component (Qiu, 2018) to identify persons at risk of dysfunction, diagnose the cause of functional decline, and select appropriate interventions for prevention and rehabilitation. Medical treatments could prioritize the upper limb mobility recure and the strength enhance. Health equity promotion moves should consider gender characteristics and original health status, such as creating a safer working environment for men, economic or social support for women, especially in inchoate and terminal dysfunction. Indeed, the whole idea types maybe not realizable; however, it is of exploratory meaning to regard it as the abstract expression of one group attribute (Wolinsky, 1999). People with different health status have substantial heterogeneity in the medical services utilization (Wolinsky and Zusman, 1980). Further, individual behaviors under different health types could be compared as a mode, chiefly, to investigate the elderly's real properties and needs under various states for formulating targeted health interventions.

# Declarations

## Ethics approval and consent to participate

The survey ethics committees of Duke University and Peking University approved the protocol for each wave of the CLHLS, which is the data source of this study.

## Consent for publication

Not applicable

## Availability of data and materials

The datasets generated and during the current study are available in the Chinese Longitudinal Healthy Longevity Survey (CLHLS) , <https://opendata.pku.edu.cn/dataset.xhtml?persistentId=doi:10.18170/DVN/XRV2WN>

## Competing interests

The authors declare that they have no competing interests.

## Funding

No funding was received.

## Authors' contributions

Shuai Fang designed research, performed research, analyzed data, and wrote the paper.

## Acknowledgments

I am grateful to my teacher Ronggui Huang, my tutor Hong Liang and my colleague Xinguo Wang for helpful suggestions and comments. The method materials and user's guide of software are from the Methodology Center Penn State. Data are from CLHLS, a program project supported by NIA/NIH grants R01 AG023627-01 directed by Y.Z, P01 AG 008761 awarded to Duke University. This project also gains help from Chinese matching personnel costs and some local expenses, cooperative funding from UNFPA, the China Social Sciences Foundation, the China Natural Sciences Foundation, and the Hong Kong Research Grants Council. The Max Planck Institute for Demographic Research has provided international training support since the baseline survey in 1998.

# References

1. Akaike H. Information Theory and an Extension of the Maximum Likelihood Principle. In: Petrov, B.N. and Csaki, F., Eds., International Symposium on Information Theory. Budapest: Akadémiai Kiadó; 1973. p. 267–281.
2. AndrewK,JoannaC,KarenD,JohnB,LouiseR,CarolJ,UlrichT.Losing the Ability in Activities of Daily Living in the Oldest Old: A Hierarchic Disability Scale from the Newcastle 85 + Study.PLoS ONE.2012;7(2):1–7.
3. BaumeisterRF,BratslavskyE,MuravenM,TiceDM.Ego depletion: Is the active self a limited resource?Journal of Personality and Social Psychology.1998;74(5):1252–1265.
4. BonsdorffMBV,RantanenT.Progression of functional limitations in relation to physical activity: a life course approach.European Review of Aging&Physical Activity.2011;8(1):23–30.
5. BrownJR,FinkelsteinA.Why is the market for long-term care insurance so small?Nber Chaps. 2007;91(10):1967–1991.
6. CampbellVACrewsJE,MoriartyDG,ZackMM,BlackmanDK.Surveillanceforsensoryimpairment,activitylimitation,andhealth-relatedqualityoflifefamongolderadults—theUnitedStates,1993–1997.MMWR.1999.<https://www.cdc.gov/mmwr/preview/mmwrhtml/ss4808a6.htm>.Accessed14Dec1999.
7. CampbellWJ,BusbyMC,RobertsonMC,LumCL,LangloisJA,MorganFC.Disease, impairment, disability, and social handicap: A community-based study of people aged 70 years and over.Disability & Rehabilitation.1994;16(2):72–79.
8. ChristensonB,JohnsonN.Educational Inequality in Adult Mortality: An Assessment with Death Certificate Data from Michigan.Demography.1995;32(2):215–229.
9. CollinsLM,LanzaST.Latent class and latent transition analysis: With applications in the social, behavioral, and health sciences.Hoboken:Wiley;2010.
10. CrimminsEM,HyunjuS,ZhangYS,KimJK.Differences between Men and Women in Mortality and the Health Dimensions of the Morbidity Process.Clinical Chemistry.2019;(1):135–145.
11. CrispimKGM,RodriguesRDC,FerreiraAP,MattosIE,SantiagoLM.Prevalence of hearing impairment in elderly patients referred to the audiology service in Manaus, Amazon.Revista Brasileira Em Promoo Da Saúde,2012;25(4)
12. DillonCF,GuQ,HoffmanHJ,ChiaWK.Vision, hearing, balance, and sensory impairment in Americans aged 70 years and over: the United States, 1999–2006.NCHS data brief.2010;(31):1–8.

13. DupreME,FranzeseAT,ParradoEA.Religious attendance and mortality: Implications for the black-white mortality crossover.Demography.2006;43(1):141–164.
14. EraPSensory, psychomotor, and motor functions in men of different ages.Scandinavian Journal of Social Medicine.1990;39:9–77.
15. FemiaEE,ZaritSH,JohanssonB.The disablement process in very late life: a study of the oldest-old in Sweden.J Gerontol Ser B Psychol Sci Soc Sci.2001;(56):12–23.
16. FerucciF,GuralnikJM,CecchiF,MarchionniN,SalaniB,KasperJ,CelliR,GiardiniS,etal.Constant Hierarchic Patterns of Physical Functioning Across Seven Populations in Five Countries.The Gerontologist.1998;38(3):286–294.
17. GreeneLSWilliamsHC,MaceraCA,CarterJS.Identifying dimensions of physical (motor) functional capacity in healthy older adults.Journal of Aging and Health.1993;5:163–178.
18. GuralnikJM,FerucciL,SimonsickEM,SaliveME,WallaceRB.Lower-Extremity Function in Persons over the Age of 70 Years as a Predictor of Subsequent Disability.New EnglandJournal of Medicine.1995;332(9):556–562.
19. HaywardMD,CrimminsEM,SaitoY.Cause of Death and Active Life Expectancy in the Older Population of the United States.Journal of Aging and Health.1998;10(2):192–213.
20. HaywardLM,BurdenML,BurdenAC,BlackledgeH,ChangYE.What is the prevalence of visual impairment in the general and diabetic populations: are there ethnic and gender differences?.Diabetic Medicine.2010;19(1):27–34.
21. HouseJS,LepkowskiJM,KinneyAM,RichardPM,RonaldCK,HerzogAR.The Social Stratification of Aging and Health.Journal of Health and Social Behavior.1994;35(3):213–234.
22. HuAN,Can education make us healthier? A comparative analysis of urban and rural areas based on the Chinese General Social Survey in 2010.Social Science in China.2014;(5):116–130.
23. HuangFWuPJ.Prediction and analysis of the long-term care needs of the elderly based on transformation probability mode.Economic Research Journal.2012;(S2):118–130.
24. JaggerC,ArthurAJ,SpiersNA,MichaelC.Patterns of Onset of Disability in Activities of Daily Living with Age.Journal of the American Geriatrics Society.2001;49(4):404–409.
25. JiaoKS.Study on the influencing factors of health inequality.Sociological Study.2014;(5):24–46.
26. JohnsonNE.The Racial Crossover in Comorbidity, Disability, and Mortality.Demography.2000;37(3):267–283.
27. KempenG,MyersA,PowellL.Hierarchical structure in ADL and IADL-analytical assumptions and applications for clinicians and researchers.Journal of Clinical Epidemiology.1995;48(11):1299–1305.
28. KimJ,DurdenE.Socioeconomic status and age trajectories of health.Social Science & Medicine.2007;65(12):2489–2502.
29. KressigRW,WolfSL,SattinRW,MichaelO,MichaelK.Associations of demographic, functional, and behavioral characteristics with activity-related fear of falling among older adults transitioning to frailty.J Am Geriatr Soc.2001;49:1456–1462.
30. LandMKC.Active life expectancy estimates for the U.S. elderly population: A multidimensional continuous-mixture model of functional change applied to completed Cohorts, 1982–1996.Demography.2000;37(3):253–265.
31. LiT,ZhangYL.Growth curve and urban-rural differences of health indicators of the elderly under the effect of the birth cohort.Population Research.2014;38(2):18–35.
32. LiuMJ,H.ZengXS.WangXS,PanL.Research Progress on the relationship between physical function and cognitive function in the elderly.Chinese General Practice.2014;17(3),242–244.
33. LynchSM,BrownJS,HarmsenKG.Black-White Differences in Mortality Compression and Deceleration and the Mortality Crossover Reconsidered.Research on Aging.2003;25(5):456–483.
34. MartinFC,HartD,SpectorT,DoyleDV,HarariD.Fear of falling limiting activity in young-old women is associated with reduced functional mobility rather than psychological factors.Age Ageing.2005;34:281–287.
35. McClintockMK,DaleW,LaumannEO,WaiteL.Empirical redefinition of comprehensive health and well-being in the older adults of the United States.Proceedings of the National Academy of Sciences of the United States of America.2016;113(22):E3071-E3080.
36. MurphySL,DubinJA,GillTM.The development of fear of falling among community-living older women: predisposing factors and subsequent fall events.J Gerontol A Med Sci.2003;58:M943-M947.
37. NamCB,WeatherbyNL,OckayKA.Causes of death which contribute to the mortality crossover effect.Social Biology.1978;25(4):306–314,283.
38. PengR,LinL,HeQ.Estimation and application of the transition probability of the health status of the elderly in China.Chinese Journal of Health Statistics.2009;26(5):480–482.
39. QiuHZ.Principle and technology of latent category model.Beijing:Education Science Press.2008.
40. QiuXL,YaoZM,YangXJ,XuSQ,LiuY,TangZ,WenJL,SunYN.Digital System for the Geriatric Somatic Function Assessment.Chinese Journal of Medical Instrumentation.2017;41(5):342–345.
41. ResnikoffS,PascoliniD,Ety'ale,D,KocurL,PararajasegaramR,PokharelGPMariottiSP.Global data on visual impairment in the year 2002.Bulletin of the World Health Organization.2004;82(11):844 – 51.
42. RogersRG.Living and dying in the USA: Behavioral, health, and social differentials of adult mortality.New York:Academic Press.2000.

43. RubinGS.Function and visual impairment in a population-based study of older adults. The SEE project. Salisbury Eye Evaluation.Invest Ophthalmol Vis.1997;38(1):72–82.
44. SchwartzG.Estimating the dimension of a model.Ann Stat.1978;6:461–464.
45. SlaugB,SchillingO,HaakM,RantakokkoM.Patterns of functional decline in very old age: an application of latent transition analysis.Aging Clinical and Experimental Research.2016;28(2):267–275.
46. SlaugB,SchillingO,IwarssonS.Defining Profiles of Functional Limitations in Groups of Older Persons: How and Why?Journal of Aging and Health.2011;23(3):578–604.
47. TinettiME.Performance-oriented assessment of mobility problems in elderly patients.Journal of the American Geriatrics Society,1986;34,119–126.
48. TunaHD,EdeerAO,MalkocM,AksakogluG.Effect of age and physical activity level on functional fitness in older adults.European Review of Aging & Physical Activity.2009;6(2),99–106.
49. VellasBJ,WayneSJ,RomeroLJ,BaumgartnerRN,GarryPJ.Fear of falling and restriction of mobility in elderly fallers.Age Ageing.1997;26:189–193.
50. VerbruggeLM,JetteAM.The disablement process.Soc Sci Med.1994;38:1–14.
51. ViljanenA,KulmalaJ,RantakokkoM,KoskenvuoM,KaprioJ,RantanenT.Fear of Falling and Coexisting Sensory Difficulties As Predictors of Mobility Decline in Older Women.The Journals of Gerontology Series A: Biological Sciences and Medical Sciences.2012;67(11):1230–1237.
52. WeiM,WangHM.Gender, urban-rural, and cohort differences in disability locus of the elderly in China.Population and Development.2017;23(5):74–98.
53. WheatonFV,CrimminsEM.Female disability disadvantage: a global perspective on sex differences in physical function and disability.Ageing & Society.2016;36(06):1136–1156.
54. WolinskyFD.The sociology of health, translated by Sun, M. H, et al. Beijing: Social Sciences Academic Press; 1999.
55. WolinskyFD,Zusman,ME.Toward Comprehensive Health Status Measure.The Sociological Quarterly.1980;21(4):16.
56. World Health Organization.International Classification of Functioning, Disability, and Health: ICF.Geneva, Switzerland:World Health Organization;2001.
57. WuXL,XuQ.Analysis of the basic physical function of the elderly.Chinese Journal of Population Science.2004;(S1):105–110,176.
58. XuW,ChenDW,ZhangCW,WangWY,SongNN.Construction and evaluation of the Chinese Mini Physical Performance Test.Journal of Nursing Science.2011;26(5):22–24.
59. ZengXK,YangYH,ChenXJ.Effect of the geriatric syndrome on body function and fall risk of type-2 diabetes mellitus.Chinese Journal of Geriatrics.2020;39(5):555–558.
60. ZengY,GuDN,Keland.The extension of healthy life expectancy estimation method and its application in the study of the elderly in China.Chinese Journal of Population Science.2007;(6):2–13.
61. ZengY,LiuYZ,XiaoZY.Socioeconomic and health status of the elderly in China.Chinese Journal of Population Science.2004;(S1):4–13.
62. ZhengL,ZenXH.Gender differences in social stratification and health inequality: a longitudinal analysis based on the life course.Chinese Journal Of Sociology.2016;36(6):209–237.

## Tables

**Table 1. Overview of the physical function of the sample at 2002, 2008 and 2014**

Physical function indicators(n(%)) <sup>a</sup>	2002			2008			2014		
	Whole sample (n=1578)	Male (n=749)	Female (n=829)	Whole sample (n=1578)	Male (n=749)	Female (n=829)	Whole sample (n=1578)	Male (n=749)	Female (n=829)
<b>Limb function limited</b>									
Hands behind neck	73(4.63)	33(4.41)	40(4.83)	126(7.99)	49(6.55)	77(9.30) <sup>b</sup>	150(9.76)	60(8.24)	90(11.12)
Hands behind lower back	66(4.18)	32(4.27)	34(4.10)	115(7.3)	44(5.88)	71(8.57) <sup>b</sup>	150(9.78)	56(7.69)	94(11.66) <sup>b</sup>
Raise arms upright	65(4.12)	30(4.01)	35(4.22)	120(7.61)	45(6.02)	75(9.06) <sup>b</sup>	145(9.45)	59(8.10)	86(10.66)
Lift weight of 5kg	193(12.23)	37(4.94)	156(18.82) <sup>c</sup>	304(19.26)	76(10.15)	228(27.50) <sup>c</sup>	638(41.11)	216(29.55)	422(51.40) <sup>c</sup>
Crouch and stand up three times	269(17.05)	71(9.48)	198(23.88) <sup>c</sup>	410(25.98)	124(16.56)	286(34.50) <sup>c</sup>	758(48.87)	290(39.73)	468(57.00) <sup>c</sup>
Walk continuously for 1km	159(10.08)	44(5.87)	115(13.89) <sup>c</sup>	336(21.29)	101(13.48)	235(28.35) <sup>c</sup>	666(42.94)	247(33.84)	419(51.04) <sup>c</sup>
Stand up from sitting without using hands	128(8.11)	49(6.54)	79(9.53) <sup>b</sup>	179(11.36)	52(6.95)	127(15.34) <sup>c</sup>	347(22.69)	135(18.57)	212(26.43) <sup>c</sup>
Pick up a book from the floor by standing	72(4.56)	26(3.47)	46(5.55) <sup>b</sup>	171(10.86)	55(7.34)	116(13.99) <sup>c</sup>	426(28.04)	162(22.47)	264(33.08) <sup>c</sup>
Turn around( $\leq$ 10 steps)	108(6.87)	36(4.81)	72(8.69) <sup>b</sup>	205(13.03)	72(9.65)	133(16.08) <sup>c</sup>	446(28.35)	176(23.59)	270(32.65) <sup>c</sup>
Vision function limited	153(9.7)	57(7.61)	96(11.58) <sup>b</sup>	333(21.24)	135(18.02)	198(23.88) <sup>b</sup>	516(33.97)	198(27.50)	318(39.80) <sup>c</sup>
Hearing function limited	56(3.55)	22(2.94)	34(4.10)	177(11.22)	76(10.15)	101(12.18)	305(19.74)	122(16.71)	183(22.45) <sup>b</sup>
<b>Overall</b>	593(35.30)	200(26.70)	357(43.06) <sup>c</sup>	871(55.37)	345(46.25)	526(63.60) <sup>c</sup>	1160(74.26)	494(66.58)	666(81.22) <sup>c</sup>
Notes <sup>a</sup> Valid sample number and percentage. <sup>b</sup> Statistical significance( $p\leq 0.05$ )between male and female elders. <sup>c</sup> Statistical significance( $p\leq 0.001$ )between male and female elders.									

Table 2  
Transition probabilities of latent status of physical function during 2002–2008,2008–2014

Latent statuses of elderly physical function					
	Completely Dysfunction	Health	Lower extremity Dysfunction	Limitation on High-intensity action	Upper limb Dysfunction
Total					
2002→2008					
Completely Dysfunction	<b>0.00</b>	7.21	57.06	35.73	0.00
Health	1.24	<b>71.99</b>	2.98	18.85	4.94
Lower extremity Dysfunction	21.22	12.34	<b>55.47</b>	10.97	0.00
Limitation on High-intensity action	6.02	29.37	10.55	<b>48.43</b>	5.63
Upper limb Dysfunction	3.54	59.10	0.00	31.93	<b>5.43</b>
2008→2014					
Completely Dysfunction	<b>17.79</b>	14.71	51.49	16.01	0.00
Health	3.14	<b>50.70</b>	11.51	32.42	2.23
Lower extremity Dysfunction	21.84	0.95	<b>62.66</b>	11.32	3.23
Limitation on High-intensity action	12.73	15.86	30.06	<b>40.10</b>	1.25
Upper limb Dysfunction	9.34	33.22	10.81	44.60	<b>2.03</b>
Male					
2002→2008					
Completely Dysfunction	<b>0.06</b>	3.64	56.33	39.97	0.00
Health	0.99	<b>80.30</b>	1.26	13.31	4.14
Lower extremity Dysfunction	13.89	33.11	29.83	23.17	0.00
Limitation on High-intensity action	5.62	27.60	8.64	50.55	7.59
Upper limb Dysfunction	3.87	69.87	3.99	22.27	0.00
2008→2014					
Completely Dysfunction	<b>25.99</b>	16.53	17.60	39.88	0.00
Health	3.29	<b>58.61</b>	8.38	27.61	2.11
Lower extremity Dysfunction	31.74	0.00	<b>61.89</b>	6.37	0.00
Limitation on High-intensity action	12.28	20.11	28.58	<b>36.63</b>	2.40
Upper limb Dysfunction	7.43	35.75	7.80	49.02	<b>0.00</b>
Female					
2002→2008					
Completely Dysfunction	<b>0.00</b>	7.90	57.82	34.28	0.00
Health	1.40	<b>62.12</b>	5.39	25.18	5.91
Lower extremity Dysfunction	24.19	0.00	<b>66.68</b>	9.13	0.00
Limitation on High-intensity action	6.11	30.80	11.04	<b>46.66</b>	5.39
Upper limb Dysfunction	3.20	49.42	0.00	37.77	<b>9.61</b>
2008→2014					
Completely Dysfunction	<b>14.64</b>	14.46	70.90	0.00	0.00
Health	3.06	<b>39.45</b>	16.24	38.75	2.50
Lower extremity Dysfunction	19.85	1.83	<b>60.77</b>	14.21	3.34

Notes: Item-response probabilities constrained invariant across times and gender;row as the initial latent status of the time interval,column as the final latent status of the time interval;bold part as the retention rate

Latent statuses of elderly physical function					
Limitation on High-intensity action	12.31	13.91	32.03	<b>40.77</b>	0.98
Upper limb Dysfunction	9.86	30.43	14.57	40.40	<b>4.74</b>
Notes: Item-response probabilities constrained invariant across times and gender;row as the initial latent status of the time interval,column as the final latent status of the time interval; <b>bold part as the retention rate</b>					

## Figures

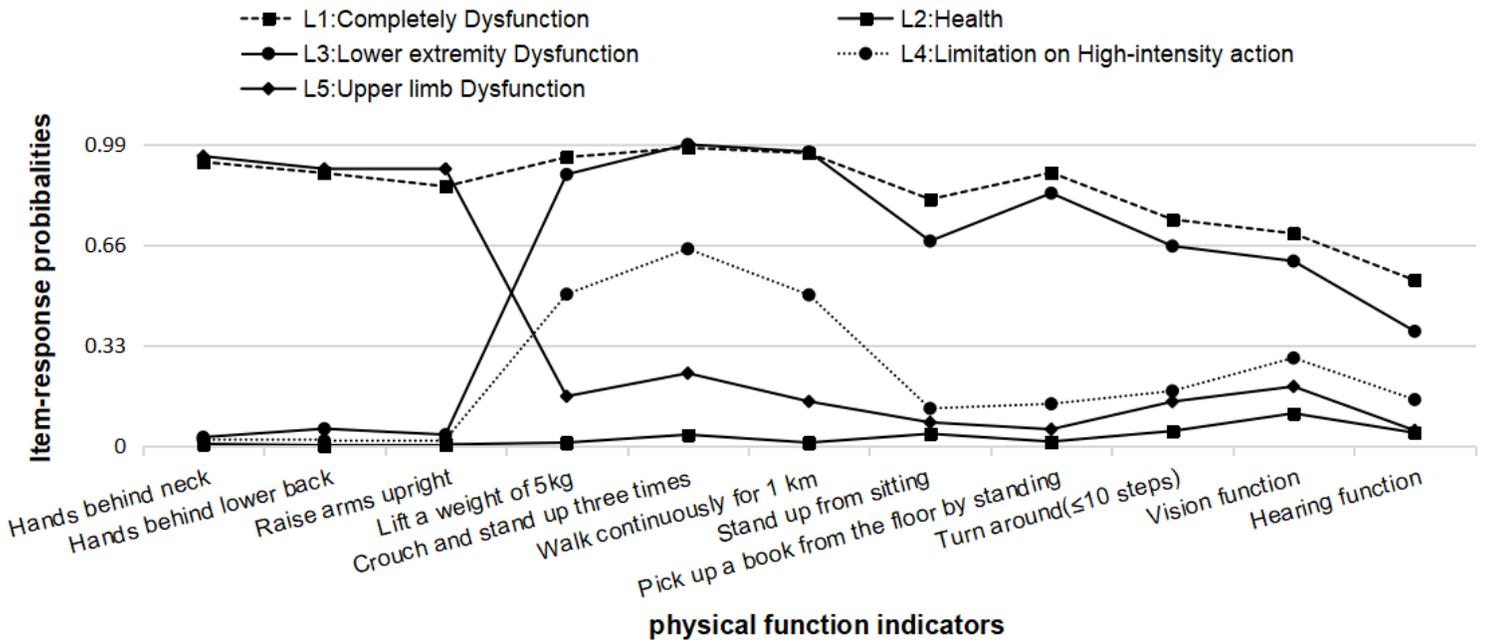
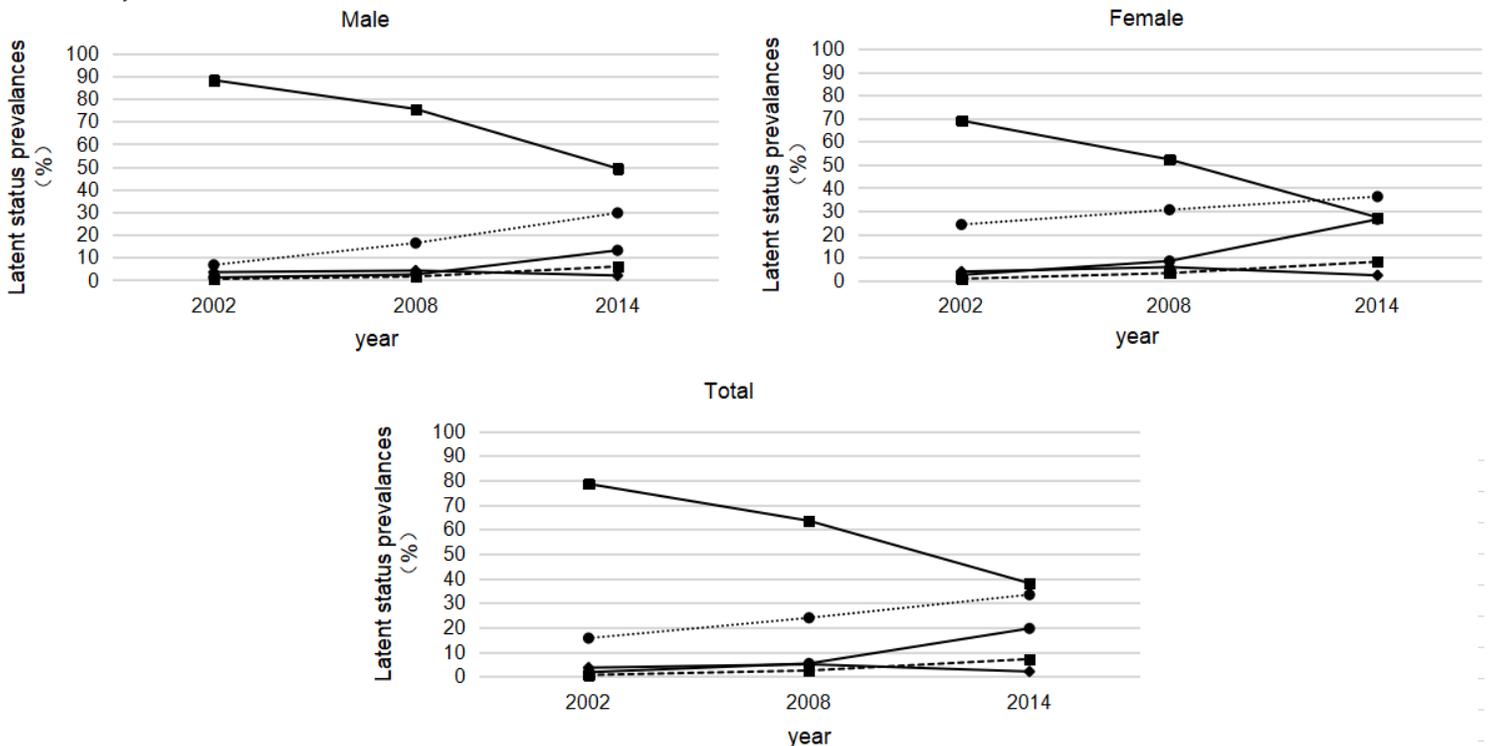


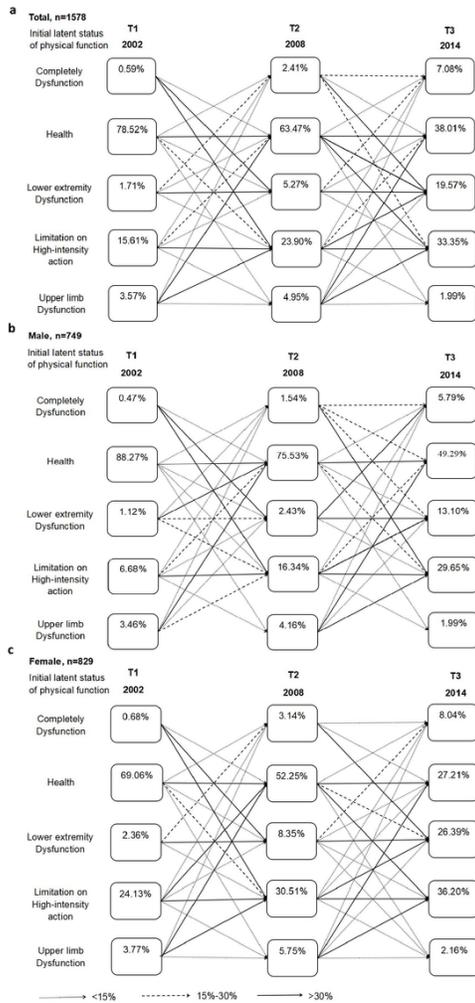
Figure 1

Five latent statuses of physical function of the elderly in China item-response probabilities of the response category as "unable to complete independently", constrained invariant across times; less 33% as low probability, 33-66% as medium probability, over 66% as high probability to define and describe each status clearly



**Figure 2**

Latent status prevalences of physical function of the sample at 2002,2008,2014 item-response probabilities constrained invariant across times and gender groups



**Figure 3**

a Illustration of probabilities for latent status transitions in the total sample over three points, T1–T3; status membership probabilities within boxes; b Illustration of probabilities for latent status transitions in the male sample over three points, T1–T3; status membership probabilities within boxes; c Illustration of probabilities for latent status transitions in the female sample over three points, T1–T3; status membership probabilities within boxes

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Additionalfile1.xls](#)