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The mediating role of intrinsic capacity in balance and falls among older adults

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The intrinsic capacity (IC) and balance function of older adults are closely related to falls. IC is not only directly related to falls but may also play a mediating role in balance and falls. This study aims to explore the mediating role of IC in balance and falls. A total of 284 elderly patients were divided into fall group (n = 131) and non-fall group (n = 153) based on whether they had experienced falls. All patients underwent assessments of IC, including locomotion (SPPB), vitality (MNA-SF), sensory (self-reported vision/hearing), cognition (MOCA), and psychological status (SAS/SDS). Patients underwent the sensory organization test and limits of stability test. (1) Using fall history as a binary dependent variable and various balance indicators as independent variables, visual (VIS) (p = 0.011, OR 0.957), vestibular function (p < 0.001, OR 0.958), and direction control (p = 0.042, OR 0.967) were negatively associated with falls. (2) After incorporating IC scores, sensory function (p < 0.001, OR 0.154), SPPB (p = 0.003, OR 0.758), and SOT-Composite (p < 0.001, OR 0.900) were negatively associated with falls, while SAS (p = 0.008, OR 1.068) was positively associated with falls. (3) IC score mediated the relationship between movement velocity (MVL) and falls. Among the five dimensions of IC, the SPPB and the MNA-SF mediated the relationship between MVL and falls, and the SPPB mediated the relationship between maximum excursion (MXE) and falls. The SAS mediated the relationship between SOM, VIS and falls, while the SDS mediated the relationship between SOM, EPE and falls. There are multiple mediating effects of IC between balance function and falls.

Keywords Elderly, Intrinsic capacity, Falls, Balance function

Abbreviations

IC	Intrinsic capacity
CDP	Computer dynamic posturography
SOT	Sensory organization test
LOS	Limits of stability test
MOCA	Montreal cognitive assessment
SAS/SDS	Self-rating anxiety and depression scale
SOM	Somatosensory
VIS	Vision
Vest	Vestibular
SOT COM	Composite equilibrium score
RT	Reaction time
MVL	Movement velocity
EPE	Endpoint excursion
MXE	Maximum excursion
DCL	Directional control

With the advancement of age, older adults often face issues of declining strength, reaction speed, physical coordination, and balance, leading to an increased risk of falls. A fall is defined as an accidental event where a person falls to the ground, floor, or lower level, including falling from one surface to another or within the same surface[1]. Falls leading to morbidity and disability in the elderly represent a serious adverse health outcome.

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There are multiple risk factors associated with falls, among which balance ability and intrinsic ability play crucial roles in the occurrence of falls.

In 2015, the World Health Organization (WHO) introduced the concept of healthy aging, and in 2017, WHO further proposed the Integrated Care for Older People (ICOPE)[2], using Intrinsic Capacity (IC) to reflect the overall function of the elderly. IC refers to the sum of all physical and mental capacities that an individual can utilize at any point in their life, which represents the body's resilience and reserve capacity of the elderly, and declines with age[3]. IC includes five dimensions: Locomotion, Vitality, Sensory, Psychology, and Cognition.

Balance is both a posture of the body and the ability to automatically adjust and maintain posture when moving or under external force, divided into static balance and dynamic balance. Maintaining balance is a key factor in independently completing most daily activities and is crucial for preventing falls in the elderly. The maintenance of human balance includes sensory input systems, central integration, and somatic motor output. Vestibular sense, vision, and proprioception are the sensory input systems for balance, while muscles, skeleton, and joints are the body's motor output systems.

The vast majority of falls in daily life occur during standing, walking, or when there is external interference[4–6]. A 5-year observational study revealed that malnourished patients are nearly eight times more likely to experience harmful falls than non-malnourished patients[7]. Good muscle strength and coordination are essential for maintaining balance[8]. Psychological conditions such as anxiety and depression can result in hyper-vigilance and muscle tension, which in turn can affect balance[9]. Cognitive abilities, particularly attention and executive functions, can improve the capacity to process information, including vision, vestibular sense, and proprioception, in order to maintain balance and adjust motor output to adapt to environmental changes[10,11]. Anxiety and depression can lead to a decrease in physical activity and social interaction among the elderly, resulting in a decline in skeletal, muscular, and joint functions, and an increased risk of falls[12]. It is evident that intrinsic capacity is significantly associated with balance and falls. However, not all elderly individuals with imbalance will experience falls, indicating that IC plays a crucial mediating role between balance and falls in the elderly.

This study intends to assess the intrinsic capacity and quantify the balance function of the elderly fall population, to analyze the mediating role of intrinsic capacity between balance and falls in older patients, providing a reference for formulating effective strategies to reduce the risk of falls in the elderly.

Methods

Participants

From January 2021 to January 2023, 284 older patients, including 209 males and 75 females, were enrolled based on whether they had experienced more than one fall in the past year from the outpatient department of geriatric medicine. Among these patients, 131 cases were assigned to the fall group, while the remaining 153 cases were in the no-fall group. All participants provided written informed consent in accordance with the Declaration of Helsinki, and the study protocol was granted approval by the ethical committee of Beijing Tongren Hospital Affiliated to Capital Medical University (approval No. TRECKY2021-042).

The inclusion criteria were as follows: (1) Age $\geq$ 60 years old, (2) capable of walking independently for a distance of 30 m, (3) possessing the ability to comprehend and communicate with others.

The exclusion criteria were as follows: (1) inability to understand and accurately cooperate with the examination, (2) being in the acute attack of heart, atrial fibrillation ,lung, and kidney diseases, (3) having severe cerebrovascular or central system disease, (4) long-term use of antidepressants, and use of sedative and hypnotic drugs in the past 2 weeks.

Data collection

The participants' age, sex, height, and weight were obtained, and the body mass index (BMI) was calculated as weight (kg)/height^2 (m^2). Diagnosis and comorbidities were obtained from medical records. Polypharmacy was defined as the use of five or more medications.

Intrinsic capacity

A dedicated nurse evaluated the intrinsic capacity of participants using the WHO ICOPE screening tool[2]. The scoring system ranged from 0 to 5, where a higher score denoted a more robust intrinsic capacity. In this study, the components of intrinsic capacity were measured as follows (see Table 1): for locomotion, we used the Short Physical Performance Battery (SPPB); for vitality, the Mini Nutritional Assessment Short Form (MNA-SF) was employed; cognitive function was gauged through the Montreal Cognitive Assessment (MOCA); sensory abilities were determined based on self-reported vision or hearing impairments affecting daily activities; and psychological well-being was assessed using the self-rating anxiety and depression scale (SAS/SDS)[13–17].

Computer dynamic posturography (CDP)

We utilized the EquiTest Dynamic Balance Bench Tester and Balance Test Board (from NeuroCom Company) for evaluating balance function. Participants were guided to react to the presented scenarios, with the collected data subsequently analyzed and processed by a computer. The Sensory Organization Test (SOT) and Limits of Stability (LOS) outcomes were computed and finalized automatically.

Sensory organization test (SOT)

The SOT involved calculating the patient's center-of-gravity shifts across six distinct sensory information scenarios. Each of these six scenarios, which lasted for 20 s, was performed thrice[18], as detailed below: (1) Fixed surface, fixed visual surroundings, eyes open; (2) Fixed surface, eyes closed; (3) Fixed surface, moving visual

IC		Score
Locomotion	SPPB ≥ 10	1
	SPPB < 10	0
Vitality	MNA-SF ≥ 12	1
	MNA-SF < 12	0
Cognition	MOCA ≥ 26	1
	MOCA < 26	0
Sensory: (hearing/vision)	No impact	1
	impact	0
Psychology	SAS/SDS < 50	1
	SAS/SDS ≥ 50	0

Table 1. Intrinsic capacity composite score. *IC* intrinsic capacity.

surroundings, eyes open; (4) Moving surface, fixed visual surroundings, eyes open; (5) Moving surface, eyes closed; (6) Moving surface, moving visual surroundings, eyes open.

Ratio scores for somatosensory (SOM), vision (VIS), and vascular (VEST) were calculated based on the scores under varying conditions. A higher score indicated a superior corresponding sensory perception. The composite equilibrium score (SOT-COM) represented the arithmetic mean of the balance percentage achieved in each SOT condition, signifying the capacity to integrate balanced sensory input.

Limits-of-stability test (LOS)
Participants were positioned on a platform, facing forward, and tasked with maintaining their center of gravity at the testing area's midpoint. Upon the appearance of a signal on the screen, they swiftly shifted their body's center of gravity to the designated area and sustained stability. After a duration of 10 s, they repositioned their center of gravity back to the testing area's center. To achieve comprehensive results via computer analysis and processing, participants were required to reach eight directional points (front, back, left, right, front-left, front-right, back-left, and back-right) surrounding their position[19].

Our main focus was on the following metrics: (1) Reaction Time (RT) is defined as the duration from the signal's appearance to the participant's commencement of body movement, quantified in seconds. (2) Movement Velocity (MVL) signifies the degree of the participant's center of gravity movement each second, quantified in degrees per second. (3) Endpoint Excursion (EPE) is the ratio of the maximum distance the participant's center of gravity can achieve while maintaining a stable tilt stand (in a static state) to the computer reference value, denoted as a percentage. (4) Maximum Excursion (MXE) is the ratio of the maximum distance the participant's center of gravity can achieve throughout the entire movement process (in a dynamic state) to the computer reference value, denoted as a percentage. Owing to the body's stability control, MXE is typically equal to or greater than EPE. (5) Directional Control (DCL) is the percentage of the linearity of the center of gravity displacement trajectory, determined by subtracting the external movement quantity (off-axis) from the movement quantity in the predetermined direction (target direction).

Statistical analyses
Statistical analysis was conducted using SPSS (Version 22). Quantitative data that were normally distributed were expressed as mean and standard deviation [mean (SD)], while non-normally distributed data were expressed as quartiles (P25–P75). The independent samples t-test and the Mann–Whitney U test were utilized to compare group differences. Qualitative data is typically presented as a proportion or percentage. A Pearson chi-squared (χ^2) test was used to compare the differences between groups. Binary logistic regression was conducted to identify the factors influencing Falls. The analysis yielded Exp (B) and its corresponding 95% confidence intervals (CI). A p-value less than 0.05 was considered statistically significant.

Finally, the PROCESS macro model 4, version 4.0 in SPSS with bias-corrected 95% confidence intervals (CIs) with 5000 bootstrapped samples was used to test the hypothesized mediation models between intrinsic capacity, balance indicators, and falls. Balance indicators was the independent variable (X), falls was the dependent variable (Y), and intrinsic capacity was the mediating variable (M). Taking into consideration the current understanding of mediation test in, in the present study, path A represents the relationship between balance indicators and intrinsic capacity, the regression coefficient is denoted as 'a'. Path B represents the relationship between intrinsic capacity and falls, the regression coefficient is denoted as 'b'. Path C represents the relationship between balance indicators and falls (total effect), the regression coefficient is denoted as 'c'. In addition, the mediation effect is the product of the a and b(a*b). If the interval does not include 0, there is mediation exist.

Results

1. Table 2 shown the characteristics of all participants. Out of 284 older adults, 131 were in the Falls group and 153 were in the No-Falls group. Patients with falls were significantly older and had a higher prevalence of coronary heart disease, cerebrovascular disease, and a history of polypharmacy compared to those without Falls ($p < 0.05$).

	Falls group (131 cases)	No-Falls group (153 cases)	$\|\chi^2/T\|$	p
Age (years)	81.38 (7.30)	77.99 (9.35)	3.426	0.001*
Sex (male, %)	67.94	78.43	3.998	0.046*
BMI	23.70 (3.34)	24.02 (2.91)	0.865	0.388
Hypertension (yes, %)	69.77	69.93	0.001	0.976
Coronary heart disease (yes, %)	54.26	33.33	12.516	< 0.001*
Diabetes (yes, %)	45.74	35.95	2.785	0.095
Cerebrovascular disease (yes, %)	32.56	11.76	18.067	< 0.001*
Chronic kidney disease (yes, %)	11.63	7.19	1.647	0.199
Multiple medication history (≥ 5, %)	68.22	38.56	24.665	< 0.001*

Table 2. Comparison of characteristics between the two groups. *BMI* body mass index. *$p < 0.05$.

	Falls group (131 cases)	No-Falls group (153 cases)	$\|\chi^2/T/Z\|$	p
IC score	3 (2, 4)	4 (3, 5)	6.385	< 0.001*
Locomotion: SPPB score	8.24 (2.41)	10.08 (2.07)	6.842	< 0.001*
Vitality: MNA-SF score	11.35 (1.90)	12.46 (1.77)	5.099	< 0.001*
Cognition: MOCA score	24.67 (3.61)	25.65 (3.26)	2.406	0.017*
Sensory: Hearing/vision (normal, %)	58.02	87.58	32.020	< 0.001*
Psychology: SAS score	36.64 (9.73)	32.50 (6.26)	4.187	< 0.001*
SDS score	37.61 (10.30)	33.96 (7.54)	3.352	0.001*

Table 3. Comparison of intrinsic capacity between the two groups. *IC* intrinsic capacity, *SPPB* short physical performance battery, *MNA-SF* mini nutritional assessment short form, *MOCA* Montreal cognitive assessment, *SAS* self-rating anxiety scale, *SDS* self-rating depression scale. *$p < 0.05$.

	Falls group (131 cases)	No-Falls group (153 cases)	$\|T/Z\|$	p
SOT				
SOM score	98 (95, 100)	98 (95, 100)	0.542	0.588
VIS score	70 (55, 80)	80 (75, 85)	7.065	< 0.001*
VEST score	30 (5.0, 65)	70 (60, 80)	8.246	< 0.001*
SOT-COM score	54 (45, 72)	76 (71, 80)	8.737	< 0.001*
LOS				
RT(s)	0.96 (0.30)	0.90 (0.26)	1.692	0.092
MVL (deg/s)	2.79 (0.69)	3.03 (0.86)	2.500	0.013*
EPE (%)	50.66 (10.05)	55.49 (10.39)	3.928	< 0.001*
MXE (%)	65.80 (12.31)	70.02 (11.16)	3.009	0.003*
DCL (%)	65.78 (12.08)	71.39 (9.53)	4.322	< 0.001*

Table 4. Comparison of the balanced functional indicators between the two groups. *SOT* sensory organization test, *SOM* somatosensory, *VIS* vision, *Vest* vestibular, *SOT-COM* composite equilibrium score, *LOS* limits of stability, *RT* reaction time, *MVL* movement velocity, *EPE* endpoint excursion, *MXE* maximum excursion, *DCL* directional control. *$p < 0.05$.

2. Table 3 presents a comparison of the intrinsic capacity between the two groups. As can be seen, there was a significant decline in IC score and dimensions of IC in the Falls group ($p < 0.05$).
3. Table 4 presents a comparison of the balanced functional indicators between the two groups. As can be seen, the VIS, VEST, SOT-COM, MVL, EPE, MXE, and DCL are all significantly lower in the fall group compared to the non-fall group ($p < 0.05$).
4. *The Relationship Between Intrinsic Capacity, Balance Ability, and Falls* With falls as the binary dependent variable, after adjusting for age, gender, and body mass index, regression models were developed. Model 1 included each balance indicator as an independent variable, while Model 2 incorporated both balance indicators and IC scores as independent variables. Figure 1 presents the odds ratios (OR) and 95% confidence intervals (CI) for both models.

    (a) Model 1, the results revealed that the VIS ($p = 0.011$, OR 0.957), VEST ($p < 0.01$, OR 0.958), and DCL ($p = 0.042$, OR 0.967) are independently associated with falls (Table 5).

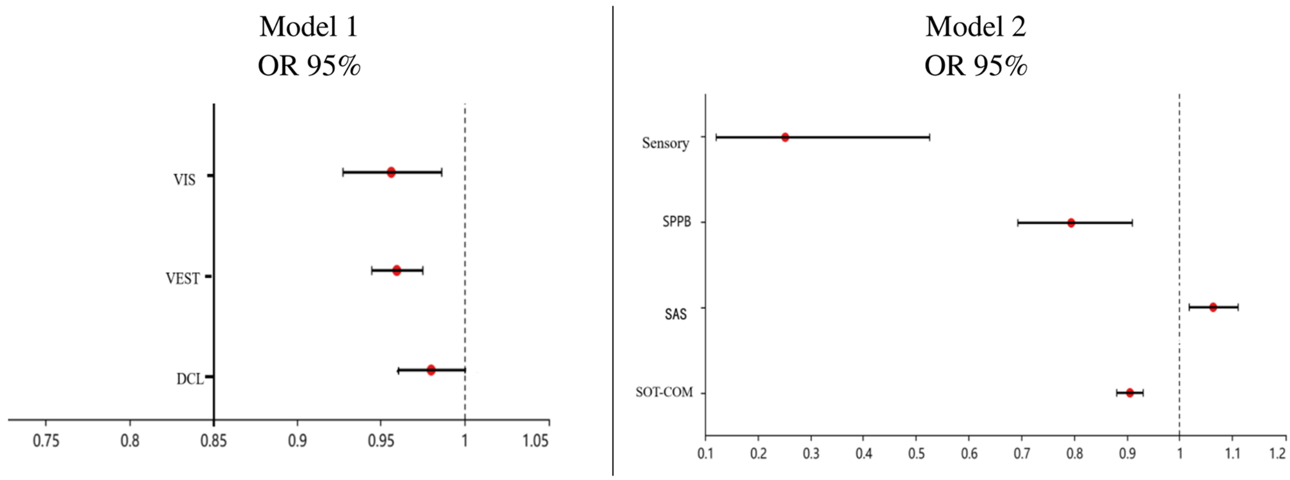

Fig. 1. Odds ratios from binary logit regression for models 1 and 2. *SPPB* short physical performance battery, *VIS* vision, *Vest* vestibular, *DCL* directional control, *SAS* self-rating anxiety scale, *SOT-COM* composite equilibrium score.

	β	p	OR	95% CI
VIS	−0.044	0.011	0.957	0.925–0.990
VEST	−0.043	0.000	0.958	0.941–0.975
DCL	−0.034	0.042	0.967	0.936–0.999

Table 5. Binary Logit regression analysis of balance function on falls. *VIS* vision, *Vest* vestibular, *DCL* directional control.

	β	p	OR	95% CI
Sensory	−1.870	0.000	0.154	0.063–0.375
SPPB	−0.277	0.003	0.758	0.633–0.908
SAS	0.066	0.008	1.068	1.018–1.121
SOT-COM	−0.105	0.000	0.900	0.874–0.928

Table 6. Binary logit regression analysis of intrinsic capacity and balance function on falls. *SPPB* short physical performance battery, *SAS* self-rating anxiety scale, *SOT-COM* composite equilibrium score.

(b) Model 2 indicates that sensory ($p<0.001$, OR: 0.154), SPPB ($p=0.003$, OR: 0.758), and SOT-COM ($p<0.001$, OR: 0.900) were negatively associated with falls, while SAS ($p=0.008$, OR: 1.068) was positively associated with falls (Table 6).

5. The mediating role of intrinsic capacity between balance and falls.

(a) The mediating effect of overall intrinsic capacity on falls and balance is shown in Table 7 and Fig. 2. MVL can influence falls through the IC. The total effect, mediating effect, and direct effect of MVL on falls are all negative, indicating a negative relationship between MVL and falls. This suggests that the faster the movement velocity, the lower the risk of falling. By improving IC, the likelihood of falls can be further reduced.

(b) The mediating effect of the five dimensions of IC between balance indicators and falls were presented in Table 8 and Fig. 3. Among the five dimensions of Intrinsic Capacity (IC), (1) SPPB was found to mediate the relationship between MVL, MXE, and falls. The total effect, direct effect, and mediating effect of MVL on falls were all negative, indicating that MVL can decrease the risk of falls by improving SPPB scores. The total effect and mediating effect of MXE on falls were negative, while the direct effect was zero, suggesting that MXE did not directly affect falls but can reduce the risk of falls by enhancing SPPB. (2) MNA-SF was found to mediate the relationship between MVL and falls. The total effect, mediating effect, and direct effect were all negative, indicating that MVL can decrease the risk of falls by improving MNA-SF scores. (3) SAS mediated the relationship between SOM and VIS with falls. SDS mediated the relationship between SOM and EPE with falls. The total effect of SAS/SDS on falls in relation to SOM

	Total effect c	a	b	Mediating effect a*b	95% BootCI	Mediation
VEST = > IC = > Falls	− 0.005	0.007	− 0.089	− 0.001	− 0.116 to 0.032	No
VIS = > IC = > Falls	− 0.003	0.010	− 0.089	− 0.001	− 0.078 to 0.016	No
SOM = > IC = > Falls	0.000	0.026	− 0.089	− 0.002	− 0.053 to 0.006	No
SOT-COM = > IC = > Falls	− 0.008	0.003	− 0.089	− 0.000	− 0.089 to 0.082	No
RT = > IC = > Falls	− 0.048	0.378	− 0.089	− 0.033	− 0.048 to 0.010	No
MVL = > IC = > Falls	− 0.062	0.277*	− 0.089	− 0.025	− 0.080 to − 0.007	Yes
EPE = > IC = > Falls	− 0.003	− 0.000	− 0.089	0.000	− 0.047 to 0.051	No
MXE = > IC = > Falls	0.001	0.017	− 0.089	− 0.002	− 0.095 to 0.010	No
DCL = > IC = > Falls	− 0.002	0.002	− 0.089	− 0.000	− 0.037 to 0.032	No

Table 7. The mediating effect of the IC score between balance indicators and falls. *IC* intrinsic capacity, *SOT* sensory organization test, *SOM* somatosensory, *VIS* vision, *Vest* vestibular, *SOT-COM* composite equilibrium score, *LOS* limits of stability, *RT* reaction time, *MVL* movement velocity, *EPE* endpoint excursion, *MXE* maximum excursion, *DCL* directional control.

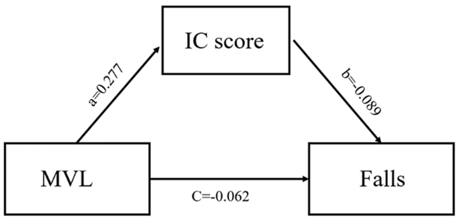

Fig. 2. The mediating effect of the IC score between balance indicators and falls. *IC* intrinsic capacity, *MVL* movement velocity. 'a' represents the regression coefficient between the balance indicator (independent variable) and intrinsic capacity (mediating variable), 'b' represents the regression coefficient between intrinsic capacity (mediating variable) and falls (dependent variable), and 'c' represents the regression coefficient between the balance indicator (independent variable) and falls (dependent variable) (total effect).

	Total effect c	a	b	Mediating effect a*b	95% BootCI	Mediation
MVL = > SPPB = > Falls	− 0.061	0.412	− 0.047	− 0.019	− 0.073 to − 0.001	Yes
MXE = > SPPB = > Falls	0.002	0.052	− 0.047	− 0.002	− 0.124 to − 0.003	Yes
MVL = > MNA-SF = > Falls	− 0.061	0.409	− 0.046	− 0.019	− 0.066 to − 0.002	Yes
SOM = > SAS = > Falls	0.000	− 0.323	0.012	− 0.003	− 0.075 to − 0.004	Yes
VIS = > SAS = > Falls	− 0.004	− 0.108	0.012	− 0.002	− 0.100 to − 0.009	Yes
SOM = > SDS = > Falls	0.000	− 0.377	0.008	− 0.003	− 0.061 to − 0.002	Yes
EPE = > SDS = > Falls	− 0.003	− 0.019	0.008	− 0.002	− 0.077 to − 0.002	Yes

Table 8. The mediating effect of the five dimensions of IC between balance indicators and falls. *SPPB* short physical performance battery, *MNA-SF* mini nutritional assessment short form, *SAS* self-rating anxiety scale, *SDS* self-rating depression scale, *SOM* somatosensory, *VIS* vision, *Vest* vestibular, *MVL* movement velocity, *EPE* endpoint excursion.

was zero, but the mediating effect was negative, suggesting that SOM did not directly impact falls, but it may influence the risk of falls through SAS/SDS. The total effect, mediating effect, and direct effect of SAS on falls in relation to VIS are all negative. Similarly, the total effect, mediating effect, and direct effect of SAS/SDS on falls in relation to EPE were all negative, indicating that VIS and EPE may influence the risk of falls through SAS/SDS.

Discussion

The incidence of falls among the elderly has been increasing year by year, becoming a global public health issue due to the aging of the population[20]. Falls are a significant cause of morbidity and mortality among older adults, representing one of the severe adverse health outcomes they face. It has become the leading cause of injury-related death among individuals aged 65 and older in China[21].

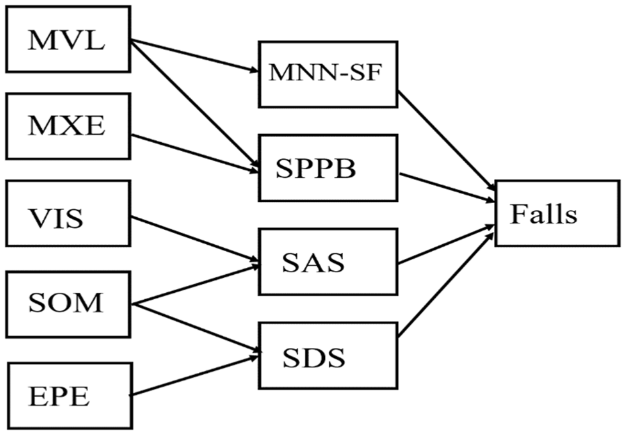

Fig. 3. The mediating effect of the five dimensions of IC between balance indicators and falls. *SPPB* short physical performance battery, *MNA-SF* mini nutritional assessment short form, *SAS* self-rating anxiety scale, *SDS* self-rating depression scale, *SOM* somatosensory, *VIS* vision, *Vest* vestibular, *MVL* movement velocity, *EPE* endpoint excursion.

This study found that elderly individuals with a history of falls have a higher comorbidity index and a higher prevalence of chronic diseases such as coronary heart disease and cerebrovascular diseases. Coronary heart disease and hypertension can affect the heart's pumping function and blood supply, leading to inadequate oxygen supply and blood pressure fluctuations, thereby affecting brain function and balance control. Inadequate blood supply can result in muscle oxygen deficiency, affecting gait and walking ability. Additionally, patients with coronary heart disease often experience arrhythmias or exacerbation of hypotension, worsening vital organ perfusion, leading to syncope and falls[22]. Cerebrovascular diseases such as stroke can cause brain damage, even directly resulting in imbalance, muscle weakness, decreased coordination, syncope, and falls[23].

In addition to traditional risk factors, this study found that intrinsic capacity and balance function are two key factors influencing the risk of falls. There is an interaction between them. Individuals with good physical health conditions have faster body responses and can adjust body posture more effectively to maintain balance. Individuals with stable psychological states have focused attention and can perceive body position and environmental changes more accurately[24]. Previous study has shown that individuals with good intrinsic capacity have better balance control ability and lower risk of falls, while individuals with poor intrinsic capacity experience a decline in balance control ability and a higher risk of falls[25]. To explore the interrelationships between intrinsic capacity, balance function, and falls, this study constructed two logistic regression models, analyzing falls as a binary dependent variable. In the first logistic regression model, balance-related indicators were used as independent variables. The results showed a significant negative correlation between falls and SPPB, VIS, VEST, and DCL. This suggests that enhancing physical function, visual ability, vestibular sensation, and directional control abilities in the elderly correspondingly reduce the risk of falls. In the second logistic regression model, various dimensions of intrinsic capacity were further included along with balance function indicators as independent variables. The analysis revealed a negative correlation between falls and perception, SPPB, and SOT-COM, while a positive correlation was found between falls and SAS. This indicates that improving perception, enhancing physical function, and integrating sensory input can reduce the risk of falls in the elderly, while effectively managing anxiety may lower the risk of falls.

After incorporating various dimensions of intrinsic capacity indicators, the impact of balance function on falls changed, suggesting that intrinsic capacity may play a mediating role between balance and falls. Therefore, this study further conducted a mediation analysis. Mediation refers to the process where the mediating variable transmits the influence between the independent and dependent variables. In this study, the independent variables were various balance indicators, the dependent variable was falls, and the mediating variables were various dimensions of intrinsic capacity. The results indicated that the mediation primarily occurred through total intrinsic capacity (IC), mobility (SPPB), vitality (MNA-SF), and psychological status. Intrinsic capacity (IC) primarily influenced falls through its impact on mobility speed; faster mobility speed was associated with lower fall risk, and improving overall intrinsic capacity could further reduce the likelihood of falls. Additionally, physical function (SPPB) and nutritional status (MNA-SF) played clear mediating roles in the relationship between mobility speed and falls. Previous study has also suggested that mobility speed reflects an individual's muscle strength and coordination, making it an effective indicator for assessing the risk of falls in the elderly[26]. Physical exercise interventions and improvements in nutritional status, particularly intake of protein, omega-3 fatty acids, and other nutrients, play a crucial role in enhancing physical function and preventing muscle loss disorders[27]. This, in turn, can help prevent falls by enhancing intrinsic capacity[28].

This study found that psychological status also plays a significant mediating role between balance and falls. Vision can directly impact falls and may also influence the occurrence of falls through changes in anxiety levels (SAS). Elderly individuals with visual impairments are more prone to experiencing anxiety, which could affect their visual-motor coordination, leading to overly cautious and unnatural movements[29]. This may impact their gait and balance, thereby increasing their risk of falls. There is a moderate correlation between proprioception and dynamic balance control, with elderly individuals relying more on proprioceptive feedback to control dynamic balance[30]. A decrease in postural stability can increase the risk of falls[31]. In this study, proprioception did not show differences between the fall and non-fall groups, but the mediation analysis revealed that proprioception can influence falls through changes in anxiety and depression levels (SAS/SDS). This may be because the patients in the study were from outpatient settings, where proprioception was relatively intact. Therefore, proprioception does not directly impact falls, but the presence of psychological factors such as depression or anxiety can mediate an increased risk of falls. Furthermore, the farthest endpoint of movement (EPE) showed a negative relationship with falls, indicating that a longer EPE is associated with lower fall risk. Depression (SDS) also played a mediating role in this relationship, suggesting that improving depressive symptoms can further reduce the likelihood of falls. These results suggest that psychological factors can directly or indirectly influence the risk of falls, and interventions targeting psychological factors may help prevent falls[32].

This study analyzed the multifaceted risk factors for falls in older adults and found that IC and its various dimensions play multiple mediating roles in balance and falls. The findings suggest that strategies aimed at improving physical function, enhancing nutritional status, and promoting mental health may help reduce the risk of falls among older adults. However, the study was limited by its small sample size and cross-sectional design, which restricts its ability to establish causal relationships between the identified risk factors and the occurrence of falls. Future research could expand the sample size and adopt a longitudinal design to enhance the validity and applicability of the findings.

Conclusion
There are multiple mediating effects of IC between balance function and falls. Targeted improvements in these intrinsic capacities may enhance balance abilities and reduce the occurrence of fall events.

Data availability
The datasets used in the current study are not publicly available due to them containing information that could compromise research participant privacy but are available from the corresponding author on reasonable request.

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Author contributions

CY conceptualized and designed the study, drafted the initial manuscript, tables, and figures, and reviewed and revised the manuscript. CY, ZJ, LQ and YH designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript. CY and LB coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

This study was conducted in accordance with the declaration of Helsinki. This study complied with the requirements of medical ethics and was reviewed and approved by the ethics committee of Beijing Tongren Hospital Affiliated to Capital Medical University (approval No. TRECKY2021-042).

Informed consent

All participants were informed of the purpose of this study and signed written informed consent.

Additional information

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