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Review article

Umbrella review of nonpharmacological interventions for intrinsic capacity in older adults

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ABSTRACT

Purpose: This study aims to synthesize existing evidence on the effectiveness of nonpharmacological interventions designed to increase the intrinsic capacity (IC) of community-dwelling older adults.
Methods: An umbrella review of systematic reviews from 2015 to October 31, 2024, with no language restrictions, was conducted. The review included five databases, including Embase, Ovid MEDLINE, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Central Register of Controlled Trials (CENTRAL), and the Joanna Briggs Institute (JBI) Library. Studies followed the preferred reporting items for overviews of reviews (PRIOR) statement. Eligible studies were systematic review and meta-analysis (SRMAs) that included any type of research aimed at enhancing IC in community-dwelling older adults (aged ≥60 years). The interventions covered seven domains: locomotion, vitality, cognitive function, psychological health, sensory function, sleep, and continence. Risk of bias and study quality were extracted via the AMSTAR tool, and GRADE approach was applied to assess the certainty of evidence.
Findings: Out of 6407 initially identified articles, 29 SRMAs comprising 400 studies with a total sample size of 43,849 participants were included. Mobility-focused interventions were the most studied among the seven domains of IC. Moderate to low-quality evidence supports the effectiveness of intrinsic foot muscle strengthening

Abbreviations: BBTi, brief behavioral therapy for insomnia; CCT, computerized cognitive training; CHF, congestive heart failure; CINAHL, Cumulative Index to Nursing and Allied Health Literature; CENTRAL, Cochrane Central Register of Controlled Trials; EAT, electronic assistive technology; IFMS, intrinsic foot muscle strengthening; IC, intrinsic capacity; ICOPE, Integrated Care for Older People; PRIOR, Preferred Reporting Items for Overviews of Reviews; RGPT, repeated gait perturbation training; SRMAs, systematic reviews and meta-analyses; VRS, virtual reality system; WHO, World Health Organization.

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and gait/muscle training for improving locomotor functions in older adults with frailty or acute functional decline. Nonpharmacological interventions targeting cognitive and psychological functions ranked second in the volume of available evidence. No effective sensory or continence interventions were identified. Overall, interventions have demonstrated varying effectiveness, with impacts ranging from moderate to very low across the domains of IC.

Interpretations: This umbrella review provides a comprehensive assessment of nonpharmacological interventions for enhancing IC in older adults, highlighting the effectiveness of mobility/muscle strength training for improving locomotor function among frail older adult or those experiencing functional decline. However, the evidence for interventions targeting other IC domains remains limited, particularly for sensory function, and continence management. Future research should prioritize high-quality trials evaluating interventions in these areas to develop evidence-based guidelines for improving overall IC and promoting healthy aging in older adults.

1. Introduction

The World Health Organization (WHO) introduced the concept of intrinsic capacity (IC) as a key element of healthy aging, emphasizing a proactive and function-based approach to older adult health (World Health Organization, 2015). This framework encompasses critical aspects, such as vitality, locomotor function, cognition, psychological health, and sensory abilities. However, there is no consensus regarding the specific dimensions that should be included in IC or how it should be measured, highlighting the need for further research to validate the constructs and measurements of IC (Gonzalez-Bautista and Beard, 2023; Hoogendijk et al., 2023). Sleep health and continence are critical dimensions in assessing the health of older people, not only as key components of comprehensive geriatric assessment (Society, 2014) but also because of their profound impact on an older person's overall functional status, health, and quality of life (Stefanacci, 2024). The WHO framework does not explicitly incorporate sleep health or continence as part of IC. However, their inclusion aligns with the WHO's goal of promoting function-based integrated care through IC, and we have included these dimensions in our analysis.

The prevalence of IC impairment is substantial in aging populations, imposing a significant burden on public health systems. One systematic review and meta-analysis that included 15 studies with a total of 43,849 participants from diverse regions in both Europe and Asia found that 67.8 % of community-dwelling older adults experience IC decline (Cao et al., 2024), raising their risk of frailty, disability, and adverse health outcomes (Charles et al., 2020; González-Bautista et al., 2021; Liu et al., 2021). Evidence suggests that IC impairment is not an irreversible process. Interventions specifically tailored to enhance IC domains have demonstrated promising outcomes. For example, multicomponent physical exercises, such as the 12-week Vivifrail program, have been shown to enhance IC, particularly in locomotion, cognition, and vitality, among frail older adults with mild cognitive impairment (Sánchez-Sánchez et al., 2022). Furthermore, individualized IC-targeted interventions, including cognitive training, psychological therapy, and nutritional support, have been effective in reducing frailty and promoting overall functional health (Tay et al., 2022).

In 2017, the WHO published "Integrated Care for Older People (ICOPE): Guidelines on community-level interventions" to manage declines in IC and emphasized the importance of establishing evidence-based interventions focused on maximizing IC (World Health, 2017). In 2019, the WHO further released "Guidance for person-centered assessment and pathways in primary care" and recommended the ICOPE screening tool to measure IC for older adults in the community (World Health, 2019). With this screening tool, health care professionals can detect declines in each IC domain and deliver interventions to prevent and delay progression, promoting healthy aging. However, uncertainty remains concerning which interventions are most effective and how these interventions should be implemented. Before an interventional approach is implemented, assessing the evidence is warranted.

IC is multifaceted, and analyzing each domain allows for a more nuanced understanding. The WHO framework on intrinsic capacity emphasizes that each domain contributes uniquely to overall capacity (World Health, 2017). However, while systematic reviews provide an efficient way to summarize evidence, existing reviews remain fragmented, as they focus on individual domains or specific aspects such as predictive value of IC for adverse health outcomes (Zhou et al., 2023), intervention efficacy in isolated domains (Bevilacqua et al., 2022), or measurement tools (George et al., 2021). This fragmented approach limits the ability to develop comprehensive, integrated intervention strategies across IC domains. Given the increasing recognition of IC as a framework for promoting healthy aging, an umbrella review is essential to synthesize the available evidence systematically.

Umbrella reviews serve as a useful starting point for decision-makers to unpack evidence for solutions to improve clinical practice and identify areas where new research is needed (Ioannidis, 2009). This paper reports the findings of an umbrella review of the evidence for interventions enhancing the IC of older adults in community and outpatient settings to 1) update and synthesize the available evidence, 2) assess which interventions are most promising with robust evidence, and 3) provide preliminary evidence for the development of effective interventions in the future.

2. Methods

An umbrella review was used to understand existing research on this topic and identify effective strategies for improving IC in the literature. The protocol for this umbrella review was registered a priori in the INPLASY database (DOI: 10.37766/inplasy2023.5.0007) on 2 May 2023 and was last updated on 23 December 2024. The updated protocol reflects the addition of JBI databases, modifications to the PICOs, the search terms used, and an extension of the search period to October 31, 2024. The review also includes articles published between 2015 and 2017. The reporting of the umbrella review is based on the Preferred Reporting Items for Overviews of Reviews (PRIOR) statement (see Supplementary Table S1) (Gates et al., 2022).

2.1. Search strategy

We identified all relevant systematic reviews and meta-analyses (SRMAs) investigating effective interventions associated with IC. We searched five multidisciplinary academic bibliographic databases, including Embase, Ovid MEDLINE, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Central Register of Controlled Trials (CENTRAL), and the Joanna Briggs Institute (JBI) Library, from 2015 to October 31, 2024, without language limitations, using terms related to interventions effective for maximizing the IC of older adults in outpatient settings. The search strategies were drafted by a researcher and an academic research librarian expert on systematic review and meta-analysis searches, and senior authors provided search suggestions. The search strategy was finalized across five databases via each platform's command language, controlled vocabulary, and appropriate search fields. Detailed documentation of the search strategy is provided in Supplementary Table S2.

We considered the older population and all types of IC, including sleep and incontinence, and summarized the short- and long-term effects

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of interventions.

2.2. Selection criteria

Eligibility for the study was determined by the population, intervention, outcome, and study design, described as follows:

2.2.1. Types of Participants

Studies were eligible if they identified community-dwelling older adults (aged ≥ 60 years) as the target population, including those with specific comorbidities such as Parkinson's disease, poststroke conditions, or mild cognitive impairment.

2.2.2. Interventions/phenomena of Interest

We did not specify selection criteria for the identified interventions because our research focused on identifying effective strategies to enhance IC among the older population. We were particularly interested in interventions conducted in outpatient or home settings aimed at enhancing intrinsic capacity in older adults.

2.2.3. Types of outcomes

The outcome measures focused on improving each domain of IC, including locomotor (including physical condition and mobility), vitality (malnutrition, frailty, and sarcopenia), cognitive (memory loss), psychological (including mood, anxiety, and depression), sensory (including hearing and visual impairment), sleep, and continence. Notably, the lack of consensus on measuring the vitality domain of intrinsic capacity is well documented in the literature (George et al., 2021). In the IC framework of the WHO, vitality primarily refers to an individual's underlying physiological reserves and metabolic health, encompassing aspects such as nutrition, physical energy, and overall biological aging (Bautmans et al., 2022). A recent study operationalized vitality using factors such as handgrip strength, muscle function, and nutritional indicators, including appetite and weight stability (Lu et al., 2023). In our study, we defined vitality using markers of frailty, sarcopenia, and malnutrition, aligning with the WHO's IC framework. The selection of outcomes of interest was performed by an interdisciplinary steering committee consisting of Y-T. Lo, H-C. Su, C. C, Y-L. Wu, S-H. Tam, C-H. Liu, C-W. Chou, Y-C. Yang, and Y-C. Chen through a thorough discussion process.

2.2.4. Types of studies

We considered all interventions evaluated by systematic reviews and meta-analyses (SRMAs), which included both RCTs and non-RCTs, to minimize selection bias. A comprehensive list of interventions considered in our umbrella review is shown in Supplementary Table S2.

2.3. Data extraction

Two investigators, YCC and CC, independently examined the titles, abstracts, and full texts of the shortlisted meta-analyses to determine eligibility. Discrepancies were resolved by consensus and thorough discussion with a third investigator, YLW. All authors independently extracted data from each systematic review and meta-analysis, and the chief investigator, YCC, verified the validity of the extracted data. The information extracted from each study included the first author/publication year, female sex (%), number of studies (cases), number of studies in MAs (cases), age, status of participants, interventions, comparisons, duration, outcome measurements, results, and value.

2.4. Data synthesis

Because the present study is an umbrella review, the included SRMAs covered a wide range of interventions and featured mixed studies targeting each domain of IC, with substantial variability in study populations, intervention types, outcome measures, and assessment methods. This considerable heterogeneity made it statistically inappropriate to combine all the included studies in a meta-analysis. Therefore, we conducted a narrative synthesis without meta-analysis (SWiM) (Campbell et al., 2020).

We organized the data into seven IC domains. The quality of the evidence for each SRMA was assessed using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) framework (Zhang et al., 2019).

2.5. Quality appraisal

The methodological evaluation of the SRMAs was conducted via the AMSTAR 2 (revised version) appraisal tool. AMSTAR 2 consists of 16 items, with three response options: yes, partial yes, and no. The scores are interpreted as follows: yes = 1, partial yes = 0.5, and no = 0. Any discrepancies that arose during the scoring process were resolved by thorough discussion and consensus establishment among the parties involved. The overall quality is divided into four levels: high (no or one noncritical weakness), moderate (more than one noncritical weakness), low (one critical flaw with or without noncritical weaknesses), and critically low (more than one critical flaw with or without noncritical weaknesses) on the basis of the AMSTAR 2 rating criteria (Shea et al., 2017).

2.6. Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report.

3. Results

3.1. Literature search

Fig. 1 shows the results of the systematic search and the selection of eligible studies. A total of 6407 articles were identified in the initial search, and 1132 duplicate articles were removed. After reviewing the titles, abstracts, and keywords, 5059 articles were excluded because they did not meet the study criteria. This left a total of 215 full-text articles that were downloaded for consideration. A total of 134 articles were excluded because the records were not retrieved. Of these, 81 articles were excluded for the following reasons: conference abstracts (n = 5), involved an unrelated population (n = 9), wrong intervention (n = 13), inconsistent outcomes (n = 15), irrelevant topic (n = 7), or not SRMA (n = 9). The reasoning for article exclusion is shown in Supplementary Table S3. Six additional articles were identified through a website search. Ultimately, 29 articles with SR and MA designs met all the inclusion criteria and were included in the qualitative synthesis.

3.2. Characteristics of the reviews

The 29 SRs and MAs are summarized in Table 1. All SRs and MAs included in this review were published between 2015 and 2024. The 29 SRs and MAs included 400 RCTs and non-RCTs with a total sample size of 43,849 participants. Sample sizes of the studies ranged from 183 to 5275 participants (Apóstolo et al., 2018; Bahar-Fuchs et al., 2019; Balbim et al., 2022; Bhatia, D. et al., 2022; Chastin et al., 2021; Chen et al., 2021; Chen et al., 2023; Corregidor-Sánchez et al., 2020; Corregidor-Sánchez et al., 2021; Dorris et al., 2021; E et al., 2020; Futrell et al., 2022; Gates et al., 2020; Hulzinga et al., 2021; Lim et al., 2022; Maranesi et al., 2020; McLaren et al., 2023; Pedersen et al., 2021; Preitschopf et al., 2023; Racey et al., 2021; Rodrigues et al., 2021; Sadaqa et al., 2023; Santos et al., 2024; Song and van der Cammen, 2019; Treacy et al., 2022; Velayati et al., 2020; Verweij et al., 2019; Wu et al., 2024). On average, the participants were 60 years old or older, with an equal distribution of males and females.

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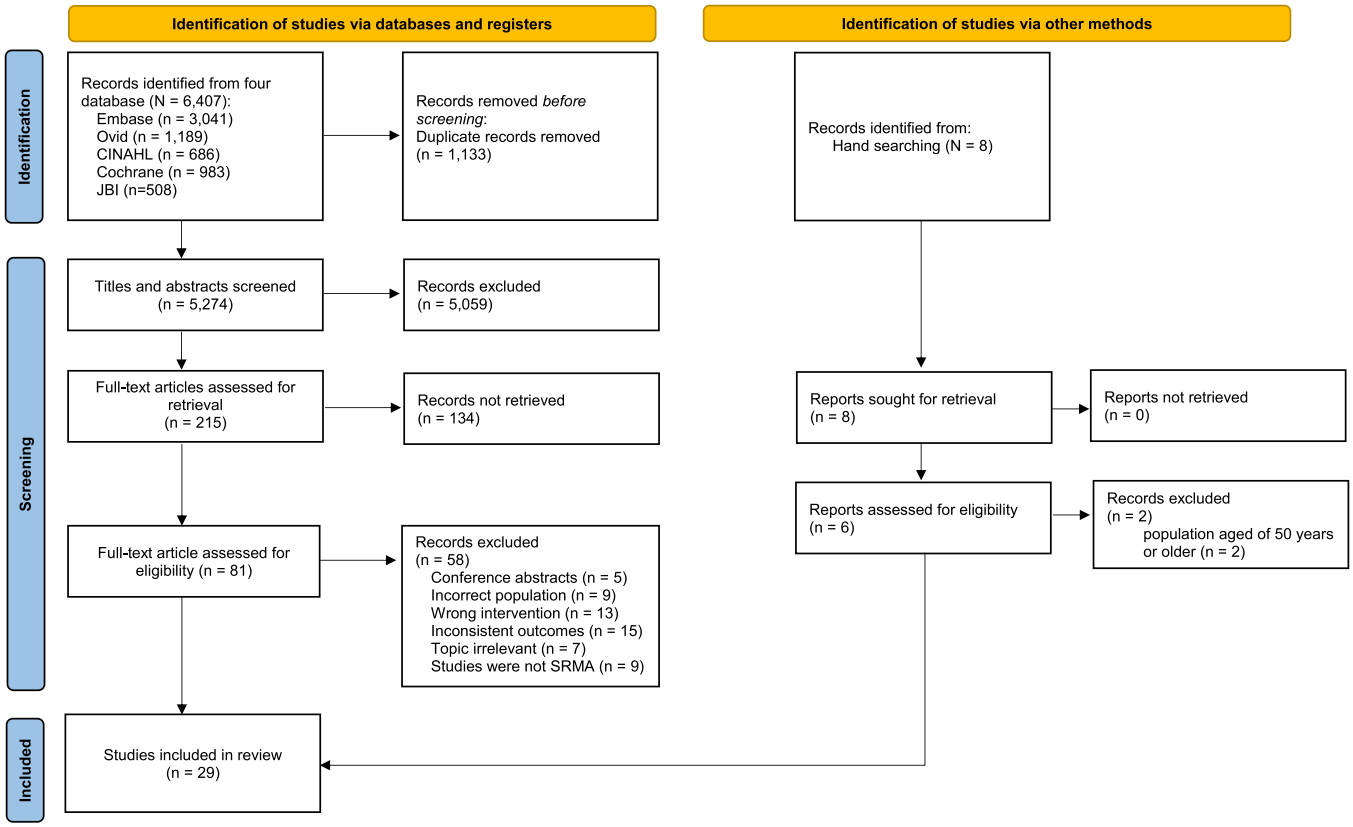

Fig. 1. PRISMA Flow Diagram of Identification and Review Selection. This figure outlines the process of identifying and selecting reviews included in the umbrella review, detailing the number of records screened, assessed for eligibility, and included in the final synthesis.

3.3. Methodological quality assessment of the included studies

According to the AMSTAR II appraisal tool, among the 29 studies, eight (34.5 %) were considered critically low quality, four (13.8 %) were low quality, and fifteen (51.7 %) were high quality. The detailed quality assessment results are shown in Supplementary Table S4.

The certainty of evidence across the 29 SRMAs ranged from very low to moderate. Specifically, 58.6 % of the evidence was categorized as very low, 27.6 % as low, and 13.8 % as moderate. These results are summarized and presented in Table 1.

3.4. Synthesis of intervention results with certainty of evidence

Among all SRMAs on IC, the majority (48.3 %) are related to the locomotor domain (14 articles, 190 studies, n = 17,782), followed by the cognitive domain (5 articles, 112 studies, n = 7790) and the psychological domain (5 articles, 56 studies, n = 10,491). Among these articles, one conducted by Wu et al. is repeatedly categorized under both the locomotor and psychological domains, as it examines the effects of cognitive behavioral therapy (CBT) on improving both cognitive and psychological capacity. The remaining studies focused on sleep quality (3 articles, 24 studies, n = 976) and vitality (2 articles, 36 studies, n = 7100). Only a few articles discussed the sensory domain (1 article, 6 studies, n = 686), and no articles specifically addressed the continence domain. The detailed distribution of evidence across the seven domains of IC is shown in Fig. 2.

We opted for a descriptive synthesis to provide a comprehensive overview of effective interventions for improving IC on the basis of the certainty of the evidence, as presented in Fig. 2. The figure underscores the certainty of evidence in determining the efficacy of non-pharmacological interventions, with particular emphasis on interventions for locomotor, cognitive, and sensory functions demonstrating substantial positive effects on improving IC among older adults, the evidence of which is supported by RCTs and non-RCTs. Here, we have listed only the effective interventions, which are classified into seven domains and stratified by different types of populations as follows:

3.4.1. Locomotor Function

3.4.1.1. Healthy. Home-based exercise (Santos et al., 2024), lower limb strengthening exercise (Sadaqa et al., 2023), and virtual reality technology (VRT) (Corregidor-Sánchez et al., 2021) significantly improved functional mobility among community-dwelling older adults.

3.4.1.2. Frailty/acute decline in function. Intrinsic foot muscle strengthening (Futrell et al., 2022) and gait/muscle training exercises (Treacy et al., 2022) provided significant benefits.

3.4.1.3. Patients with Parkinson or stroke. Robotic-assisted gait training has a positive effect (Maranesi et al., 2020).

3.4.2. Cognitive Function

3.4.2.1. Patients with dementia. Exercise training (Balbim et al., 2022), active music-making interventions (Dorris et al., 2021), cognitive training (Bahar-Fuchs et al., 2019), and computerized cognitive training (Gates et al., 2022) have significant benefits.

3.4.2.2. Patients with Parkinson's disease. Cognitive behavioral therapy (Wu et al., 2024) is effective.

3.4.3. Sensory Function

3.4.3.1. Patients with visual impairment. There is no effective strategy;

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Table 1
Characteristics of included studies.

Author/ Year	Female (%)	No. of studies (Cases)	No. of studies in MA (Cases)	Age	Status of participants	Intervention	Comparison	Duration	Outcome Measurements	Results (-/↑/↓)	Value	Certainty[a]
Locomotor												
Santos et al./(2024)	No mention	11 RCTs (n = 1004)	No meta-analysis	≥ 60	Community-dwelling older adults	Home-based exercise programs	- Usual care	5 weeks to 6 months	**Mobility:** TUG test, gait speed, muscle and handgrip strength, strength endurance	(↑)	NA	Very Low
Preitschopf et al./(2023)	No mention	24 RCTs (n = 3405)	8 (n = 1038)	≥ 65	- Acute decline in function - Having complex disease or multi-morbidity in the sub-acute phase	Rehabilitation at home and/or in an outpatient setting	- Usual care	At least 3 weeks	**Functional mobility:** Barthel index	(-)	Overall SMD= 0.11 (95 % CI −0.11–0.34)	Low
Sadaqa et al./(2023)	No mention	29 RCTs (n = 4330)	No meta-analysis	≥ 65	Community-dwelling adults	- Lower limb strengthening exercise training - Balance exercise training - Multi-component exercise training	- No intervention	1 week to 2 years	**Functional mobility:** - Muscle strength, balance, gait and mobility - Lower extremities strength, static balance, proactive balance, reactive balance, and mobility	**(↑)** **(↑)**	NA NA	Very Low
Bhatia et al./(2022)	No mention	5 mixed studies (n = 820)	5	≥ 65	Community-dwelling older adults	Outdoor community ambulation	NA	6 weeks to 12 months	**Walking endurance:** (6MWT)	(-)	MD= −0.61 (95 % CI −22.48–21.27)	Very Low
Futrell et al./ (2022)	60–100 %	9 mixed studies[¶] (n = 1674)	No meta-analysis	≥ 65	Ambulatory + /- assistive device	Intrinsic foot muscle strengthening activities	- No intervention - Home-based exercise	6 weeks to 12 months	**Physical condition:** Toe strength **Adverse events & Functional mobility:** Balance function **Functional mobility:** TUG, expanded TUG, gait speed, step length, step duration, tempo, and joint angles during gait	**(↑)** **(-)** **(↑)**	NA NA NA	Low
Treacy et al./ (2022)	73 %	12 RCTs (n = 1317)	12 (n = 1317)	≥ 60	- Being frail - Living in community	- Gait or balance functional training - Strength or	- Usual care - Nonactive control	6 weeks to 1 year	**Functional mobility:** SPPB, TUG,	**(↑)** **(↑)** **(-)**	Overall SMD= 0.47 (95 % CI 0.24–0.71)	Moderate

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Table 1 (*continued*)

Author/ Year	Female (%)	No. of studies (Cases)	No. of studies in MA (Cases)	Age	Status of participants	Intervention	Comparison	Duration	Outcome Measurements	Results (-/↑/↓)	Value	Certainty[a]
						resistance training - Flexibility training - 3D (Tai Chi, dance, etc) - General physical activity - Endurance			walking distance, walking distance and speed, timed sit to stand, Berg Balance Scale, single leg stand time **Physical Function:** Barthel Index **Adverse events:** Number of fallers		Overall SMD= 0.60 (95 % CI 0.21–1.00) SMD= 1.02 (95 % CI 0.87–1.20)	
Pedersen et al./ 2022	69 %	3 RCTs (n = 183)	No meta-analysis	> 50 (mean ≥55)	Healthy	Physical activity (Group-level, self-monitoring, weekly goal setting)	- Without PA - Self monitoring	6 weeks	**-Physical health (Self-perception):** Community CHAMPS, 6MWT, Blood pressure + heart rate + respiratory rate, step count	**(-)**	NA	Very Low
Chastin et al./ (2021)	71.5 %	7 RCTs (n = 397)	7 (n = 397)	≥ 60	- Healthy - Living independently	Behavioral change interventions	- No intervention - Not target sedentary behavior	12–20 weeks	**Functional mobility:** SPPB, Gait speed, 6MWT, Chair stand tests **Physical condition:** Body fat, Waist circumference, BMI, Blood pressure, HDL cholesterol, Triglycerides, Glucose blood levels	**(-)** **(-)**	No significant difference at all No significant difference at all	Low
Hulzinga et al./ (2021)	No mention	8 RCTs (n = 209)	6 (n = NA)	66.4 (Parkinson's), 76.2 (Healthy)	Parkinson's & Healthy	Repeated gait perturbation training (RGPT)	Non-RGPT	1 day to 4 months	**Functional mobility:** gait speed, step length, stride length, balance performance	**(-)**	SMD = 0.16 (95 % CI −0.18–0.49; $p = 0.36$)	Moderate
Corregidor-Sánchez et al./ (2021)	71 %	16 RCTs (n = 568)	16 (n = 568)	> 60	- Healthy - Walk independently	Virtual reality technology (VRT)	- Other functional mobility intervention technique - No intervention	2–24 weeks	**Functional Mobility:** TUG 6MWT	**(↑)** **(↑)**	SMD= −1.02 (95 % CI −1.91 to −0.14) SMD= −1.20 (95 % CI −1.93 to −0.46) ; > 18 sessions (SMD =−0.89;	Low

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Table 1 (*continued*)

Author/ Year	Female (%)	No. of studies (Cases)	No. of studies in MA (Cases)	Age	Status of participants	Intervention	Comparison	Duration	Outcome Measurements	Results (-/↑/↓)	Value	Certainty[a]
											95 % CI −1.71 to −0.08; $p < 0.001$)	
Velayati et al./ (2020)	No mention	8 RCTs (n = 434)	No meta-analysis	≥ 60	- Post-Stroke Disorder - Comorbidity of COPD and CHF - Post-Knee Surgery - COPD	Online or offline telerehabilitation interventions	Traditional rehabilitation services	10 days to 4 months	**Physical condition:** Upper limb movement in post stroke disorder group; Ashworth scale & ABILHAND scale **Functional mobility:** Berg Balance Scale, Barthel Index, 6MWT, physical activity profile, COPD Assessment Test (CT) **Post-Knee Surgery:** active knee extension range **COPD:** 6MWT, Incremental Shuttle Walk Test, quality of life, and COPD Assessment Test	**(-)** **(↑)** **(-)** **(-)**	NA **6MWT** ($p < 0.001$), Dyspnea ($p = 0.05$), **Physical activity profile** ($p < 0.001$), **BARTHEL** ($p < 0.001$), **CT** ($p < 0.01$) NA NA 1 study: **Endurance Shuttle Walk** ($p = 0.001$)	Very Low
Corregidor-Sánchez et al./ (2020)	93 %	23 RCTs (n = 1595)	23 (n = 1595)	> 60	- Healthy - Living independently	Virtual reality systems (VRSs)	Conventional treatment	1–24 weeks	**Functional Mobility:** FGA, TUG, FSST, 6MWT, 8-foot up and go and Five Sit to Stand **Physical function:** ADLs, BADL, Barthel Index, FIM, LLF&DI, IADL	**(↑)** **(↑)**	Overall (SMD= −0.63; 95 % CI: −0.86 to −0.40; $p = 0.001$) **BADL** (SMD=0.61; 95 % CI −0.15–1.37; $p < 0.001$); **IADLs** (SMD= −0.34; 95 % CI −0.82–0.15; $p < 0.001$)	Very Low
Maranesi et al./ (2020)	33.8 %	20 RCTs (n = 591)	No meta-analysis	≥ 60	Subacute stroke	Robotic-assisted gait trainer	Conventional rehabilitation therapy	3 weeks to 3 months	**Functional mobility:** gait speed, FAC, 6MWT, Barthel index, Berg balance scale, RMI, 10 MWT, EMS	**(↑)**	NA	Very Low

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Table 1 (*continued*)

Author/ Year	Female (%)	No. of studies (Cases)	No. of studies in MA (Cases)	Age	Status of participants	Intervention	Comparison	Duration	Outcome Measurements	Results (-/↑/↓)	Value	Certainty[a]
Verweij et al./ (2019)	No mention	15 RCTs (n = 1255)	12 (n = NA)	≥ 65	Acute decline in function	Post acute Multidisciplinary Rehabilitation	- Usual care - Other forms of rehabilitation	2 weeks to 12 months	**Functional mobility:** 6MWT	**(-)**	The overall MD= 23 (95 % CI −1.34–48.32)	Very Low
Cognitive												
Wu_2024	No mention	22 RCTs (n = 1053)	22	> 60 (20 studies)	Parkinson's disease patients	Cognitive behavioral therapy (CBT)	- Placebo treatment or without CBT treatment	1 week to 6 months	**Cognition:** MoCA **Depression:** HAM-D, BDI, GDS−15 **Anxiety:** HAM-A, BAI	(↑) (↑) (-)	MD= 0.23, 95 % CI: 0.03–0.44 MD= −3.94, 95 % CI −6.47 to −1.42 MD= −2.01, 95 % CI −4.01–0.01	Very Low
Balbim et al./(2022)	63.9 %	28 RCTs (n = 2158)	25 (n = 185)	≥ 60	Older adults living with dementia	Exercise training - aerobic training - resistance training - multicomponent training	- Usual care	At least 8 weeks, once weekly	Cognitive function	**(↑)**	g= 0.19 (95 % CI 0.05–0.33	Low
Dorris et al./ (2021)	No mention	21 RCTs (n = 1472)	9 (n = 495)	> 65	Mild cognitive impairment/ Mild to moderate dementia	Active music	- Non active music [Gymnastics, walking exercises, Music listening, Dance, Self-directed activities et al.] - Usual care	4–40 weeks	**Global cognitive functioning:** MMSE **Mood:** Mini-Emotional Well-being: Positive and Negative Affect Schedule, BDI	**(↑)** **(-)** **NA**	SMD= 0.30 (95 % CI 0.10–0.51, n = 495)	Moderate
Gates et al./ (2020)	No mention	8 RCTs (n = 1183)	8 (n = 1183)	≥ 65	- Healthy - Without cognitive problems	Computerized cognitive training (CCT)	- Active control (Educational video) - Inactive control	12–26 weeks	**Global cognitive functioning:** MMSE, ADAS-Cog, RBANS, CAMCOG	**(↑)**	SMD= −0.31 (95 % CI, −0.57 to −0.05, n = 232)	Very Low
Bahar-Fuchs et al./ 2019	No mention	33 RCTs (n = 1924)	32 (n = NA)	≥ 65	Mild to moderate level of Dementia	Cognitive training (CT)	- Usual care - Active control (Social support groups or instructed/non-specific cognitive activity et al.)	2–104 weeks	**Global cognitive functioning:** MMSE	**(↑)** **(-)**	**Compared with usual care group** SMD= 0.42 (95 % CI 0.23–0.61; n = 1389) **Compared with active control group** SMD= 0.21 (95 % CI −0.23–0.64; n = 769)	Low
Sensory												
E et al./ (2020)	69 %	6 RCTs (n = 686)	No meta-analysis	≥ 60	- Irreversible visual impairment - Live independently or in residential settings	Environmental + /- behavioral interventions	- Placebo - Usual care - No intervention	8 weeks to 1 year	**Objective measures:** Body fixed sensor activity monitoring **Self-reported:** Physical Activity Scale for the Elderly,	**(-)** **(-)** **(-)**	**Environmental intervention** *a. Physical* activity at 6 months No difference *b. Fall measures* (RR 0.76; 95 % CI 0.38–1.51) **Behavioral**	Very Low

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Table 1 (*continued*)

Author/ Year	Female (%)	No. of studies (Cases)	No. of studies in MA (Cases)	Age	Status of participants	Intervention	Comparison	Duration	Outcome Measurements	Results (-/↑/↓)	Value	Certainty[a]
									Community Healthy Activities Model Program for Seniors, Single questions on physical activity		**intervention** *a. Physical activity* at 6 months (MD= 9.1; 95 % CI, −13.85–32.5) b. *Fall measures* (RR 0.54; 95 % CI 0.29–1.01) **Environmental and behavioral intervention** *a. Physical* activity at 6 months No difference *b. Fall measures* (RR 0.97; 95 % CI 0.54–1.77)	
Sleep												
Chen et al., (2023)	70 %	4 RCTs (n = 190)	4 (n = 190)	≥ 60	Chronic insomnia	Brief behavioral therapy for insomnia (BBTi)	- Usual care - No intervention	4 weeks	PSQI, ISI, TST, WASO, SE, SOL	(↑)	4-week BBTi significantly improved total scores of sleep quality in community-dwelling older adults with chronic insomnia (SMD: −1.07, 95 % CI: −1.43, −0.71, I^2= 0 %)	Low
McLaren et al., (2023)	68.1 %	15 Mixed studies (n = 498)	NA	≥ 60	Insomnia	Behavioral intervention: Sleep Restriction and - Stimulus Control	- Active group - Passive group - No control group	2–6 sessions	Subjective: SOL, WASO, TST, SE, SQ, PSQI - Objective: PSG, Acti-watch	(↑) (-)	**NA**	Very low
Chen et al., (2021)	No mention	5 RCTs (n = 288)	5 (n = 288)	≥ 60	Sleep disturbance	Music therapy (sedative music with 60–80 Hz)	- Usual care - No intervention	2 days to 3 months	PSQI	(↑) (↑)	**1) Older adults who listened to music experienced significantly** [mean difference (MD): −1.96, 95 % CI −2.23 to −1.73, $p = 0.003$]. **2) Listening to music for longer than 4 weeks** (MD: −2.61, 95 % CI −4.72 to −0.50, $p = 0.02$)	Low
Psychological												

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Table 1 (*continued*)

Author/ Year	Female (%)	No. of studies (Cases)	No. of studies in MA (Cases)	Age	Status of participants	Intervention	Comparison	Duration	Outcome Measurements	Results (-/↑/↓)	Value	Certainty[a]
Wu_2024	No mention	22 RCTs (n = 1053)	22	> 60 (20 studies)	Parkinson's disease patients	Cognitive behavioral therapy (CBT)	- Placebo treatment or without CBT treatment	1 week to 6 months	**Depression:** HAM-D, BDI, GDS−15 **Anxiety:** HAM-A, BAI	(↑) (-)	MD= 0.23, 95 % CI: 0.03–0.44 MD= −3.94, 95 % CI −6.47 to −1.42 MD= −2.01, 95 % CI −4.01–0.01	Very Low
Bhatia et al./ (2022)	No mention	5 mixed studies¶ (n = 820)	5 (n = 820)	≥ 65	- Healthy - Community-dwelling	Community ambulation interventions (shifting or changing the position of the body, transferring from one surface to another, walking on uneven terrains)	-Educational workshop - Multicomponent circuit training - Usual care - No intervention	6–52 weeks	**Mood:** GDS, HAD	**(-)**	**3 studies**, with low certainty evidence (SMD: 0.13, 95 % CI: −0.46, 0.20, I^2 = 18 %). **1 study** with a sensitivity analysis, with very low certainty evidence (SMD: 0.36; 95 % CI: −0.61, −0.12, I^2 = 0 %).	Very Low
Lim et al./ (2022)	No mention	6 mixed studies¶ (n = 2075)	No meta-analysis	≥ 65	- Having depression or anxiety - With one or more chronic medical illnesses - Low overall physical health	Remote care management (i.e., pain care management/ telephone case management)	- Monitoring only usual care - Telephone reassessment only - No formal disease - Usual care	3 months to 3 years	**Mood:** GAD−7, GDS, PHQ−9	**(-)**	NA	Very Low
RODRIGUES et al./ 2021		7 RCTs (n = 1589)	No meta-analysis	≥ 65	Mild cognitive impairment/ dementia	Moderate to intense aerobic and muscle strengthening exercises			**Mood:** behavioral and psychological symptoms	**(↑)**	**NA**	Very Low
Song and van der Cammen/ (2019)	66 %	16 mixed studies¶ (n = 4954)	No meta-analysis	≥ 60	Living alone	Electronic assistive technology (EAT)	Non-EAT	3.3–33 months	**Mood:** GDS, MMSE	**(-)**	NA	Very Low
Vitality												
Racey et al./ (2021)	59 %	15 mixed studies¶ (n = 1825)	15 studies (n = 1825)	≥ 65	Prefrail or Frail	Nutrition trial Combined-Nutrition trial with exercise	Usual care	3 weeks to 1 year	Frailty (Fried's frailty phenotype, SHARE-FI [modified from Fried's frailty phenotype])	**(↑)** **(↑)**	**Nutrition trial** SMD= –0.22 (95 % CI= –0.44 to –0.01) **Combined-Nutrition trial with exercise** SMD= –0.41 (95 % CI= –0.68 to –0.14); RR= 0.72 (95 % CI= 0.52–1.00)	Moderate
Apóstolo et al./ (2018)	49 %	21 RCTs (n = 5275)	No meta-analysis	≥ 65	Prefrail or Frail	Physical exercise program Nutritional supplement	- Without education - Placebo	4 weeks to 18 months	**Frail status:** Frailty Index, Fried's frailty criteria, BMI	**(↑)**	NA	Very Low

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Table 1 (*continued*)

Author/ Year	Female (%)	No. of studies (Cases)	No. of studies in MA (Cases)	Age	Status of participants	Intervention	Comparison	Duration	Outcome Measurements	Results (-/↑/↓)	Value	Certainty[a]
						Cognitive training Combined physical, nutritional, and cognitive training.	- Usual care - No intervention					
Incontinence NA												

Note: IC= intrinsic capacity, CI = confidence interval, RR = risk ratio, SMD = standardized mean difference, MD = mean difference, RCT = Randomized controlled trial, A/T = assessment and treatment, NA = not applicable

[¶] Mixed studies refer to the included research that comprises randomized controlled trials as well as non-randomized controlled trials, including cohort and retrospective studies

(-) indicates that the intervention has no significant effect on increasing or decreasing the outcome measurement variable; **(↑)** indicates that the intervention significantly increases the outcome measurement variable; (↓) indicates that the intervention significantly decreases the outcome measurement variable.

Locomotor: time up and go (TUG), short physical performance battery (SPPB), 6-minute walk test (6MWT), Functional Gait Assessment (FGA), Four Step Square Test (FSST), Basic Activities of Daily Living (BADL), Functional Independence Measure (FIM), Late Life Function and Disability Instrument (LLF & DI), Lawton Instrumental activities of daily living (IADL), activities of daily living (ADL), EMS = Elderly Mobility Scale, FAC = Functional Ambulation Category

Cognitive: Montreal Cognitive Assessment (MoCA), Mini Mental State Examination (MMSE), Alzheimer's Disease Assessment Scale (ADAS-Cog), Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), Cambridge Cognition Examination (CAMCOG), The Beck Depression Inventory (BDI)

Psychological domain: Geriatric Depression Scale (GDS), Mini-Mental State Examination (MMSE), Hospital Anxiety and Depression scale (HAD), General Anxiety Disorder-7 (GAD-7), and Patient Health Questionnaire-9 (PHQ-9)

Sensory: Health related Quality of Life (HRQOL), short form-36 (SF-36), EQ-5D, Voice related Quality of Life (VRQOL), Visual Functioning-14 (VF-14), National Eye Institute Visual Functioning Questionnaire (NEI-VFQ), Low Vision Quality of Life questionnaire (LVQOL)

Sleep quality: total sleep time (TST), wake after sleep onset (WASO), sleep efficacy (SE), sleep of latency (SOL), and questionnaires included Pittsburg sleep quality index (PSQI), sleep quality (SQ), and insomnia severity index (ISI)

Vitality: Frailty Instrument of the Survey of Health, Ageing and Retirement in Europe (SHARE-FI), body mass index (BMI)

[a] The GRADE Working Group categorizes the certainty of evidence into four levels: high (very confident that the true effect is close to the estimated effect), moderate (moderately confident; the true effect is likely close to the estimate but could differ substantially), low (limited confidence; the true effect may differ significantly from the estimate), and very low (minimal confidence; the true effect is likely to differ significantly from the estimate)

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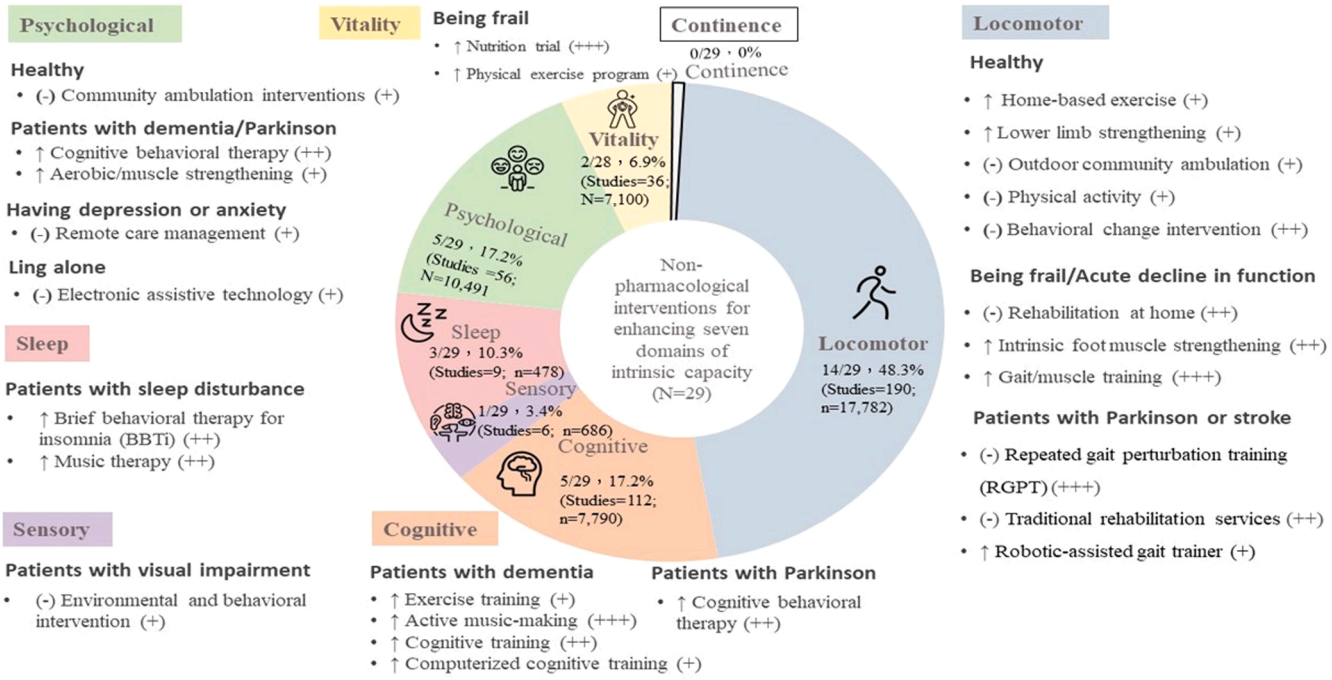

Note: + represent the level of certainty of evidence. ++++ means high certainty of evidence. Investigators are very confident that the effect across studies is close to the true effect. The evidence is robust, with consistent findings and minimal bias. +++ means moderate certainty of evidence. Investigators are moderately confident in the effect estimate. The true effect is likely to be close to the estimate, but there is a possibility it could differ. ++ means low certainty of evidence. The effect estimate is uncertain. Limited confidence due to variability in results, potential bias, or insufficient data. + means very low certainty of evidence. The evidence is very uncertain. The true effect is likely to be substantially different from the estimated effect due to serious limitations in the studies.

Fig. 2. Effective Strategies for Improving the Intrinsic Capacity of Older Adults. This figure summarizes the strategies identified in 23 SRMAs that are effective in enhancing intrinsic capacity in older adults. It highlights the interventions and their impacts on various domains of intrinsic capacity.

environmental and behavioral interventions have limited efficacy (E et al., 2020).

3.4.4. *Sleep Function*

3.4.4.1. Patients with sleep disturbance. Brief behavioral therapy for insomnia (BBTi) (Chen et al., 2023; McLaren et al., 2023) and music therapy with a sedative rhythm between 60 Hz and 80 Hz (Chen et al., 2021) has some significant benefits.

3.4.5. *Psychological Function*

3.4.5.1. Patients with dementia/Parkinson. Cognitive behavioral therapy (Wu et al., 2024) and aerobic/muscle strengthening exercise (Rodrigues et al., 2021) significantly improve psychological indicators.

3.4.6. *Vitality Function*

3.4.6.1. Patients with frailty. Nutritional supplementation, nutritional trials combined with exercise (Racey et al., 2021), and multiple interventions, such as combinations of physical exercise, nutritional supplementation, and cognitive training (João Apóstolo et al., 2018), demonstrated moderately positive effects in improving frailty among older adults.

3.4.7. *Continence Function*

No effective interventions were identified in this category.

4. Discussion

We reviewed 29 SRMAs exploring interventions to improving IC among older adults in community and outpatient settings published between 2015 and 2024, including 424 RCTs and non-RCTs with a total sample size of 44,825 participants. Our findings reveal that enhancing mobility across the seven domains of IC is most popular among older adults. The results aligned with a narrative review conducted by Freiberger et al. (2020), which highlighted that global demographic changes and growing recognition of the importance of physical function and mobility in older age have made this an increasingly significant topic (Freiberger et al., 2020). We discovered substantial nonpharmacological evidence supporting the effectiveness of various interventions to improve locomotor function in older adults who are healthy, prefrail or having Parkinson or stroke. These interventions include home-based exercise, lower limb strengthening, intrinsic foot muscle strengthening, gait/muscle training exercise and robotic-assisted gait trainers.

Nonpharmacological interventions targeting cognitive and psychological functions in older adults ranked second in the volume of available evidence. Several strategies, include cognitive behavioral therapy, physical exercise, active music-making interventions, cognitive training, and computerized cognitive training, particularly those focusing on older adults with dementia or Parkinson disease, have demonstrated significant benefits in enhancing cognitive functions. Our findings align with previous studies indicating that approximately 40 % of individuals with mild cognitive impairment may revert to a normal cognitive state due to increased anterior insula connectivity (Avila-Villanueva and Avila, 2024), which has been observed to enhance functional connectivity with the anterior cingulate cortex (Li et al., 2024). While our findings corroborate existing evidence, they also highlight opportunities for further exploration. For instance, although CBT was identified as a promising strategy, the comparative effectiveness of CBT versus other approaches, such as active music-making or physical exercise, remains underexplored in specific subpopulations. Moreover, the mechanisms by which these interventions contribute to cognitive improvement—such as neuroplasticity or psychosocial engagement—warrant further investigation to optimize the intervention design.

Our review highlights the limited evidence supporting non-pharmacological interventions for improving psychological well-being among older adults, with the included studies demonstrating varying

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levels of effectiveness across different interventions. CBT has shown moderate benefits in reducing depression in Parkinson disease patients (Wu et al., 2024), which is consistent with findings from prior research emphasizing the role of CBT in managing late-life depression in older adults (Bilbrey et al., 2022). In addition, moderate-to-intense aerobic and muscle-strengthening exercises are associated with improvements in behavioral and psychological symptoms in older adults with mild cognitive impairment or dementia (Rodrigues et al., 2021). This aligns with growing evidence that physical activity can have antidepressant effects through biological and psychosocial pathways (Hird et al., 2024). However, the evidence for other interventions, such as remote care management using telephone-based approaches (Lim et al., 2022) and electronic assistive technologies (EATs) (Song and van der Cammen, 2019), is weak or inconclusive. Several potential factors, including the absence of direct physical interaction and continuous monitoring, could diminish the effectiveness of such interventions in enhancing mood, and many older adults may encounter difficulties in utilizing new technologies, which may contribute to this outcome. Effective mood improvement often necessitates a holistic approach that integrates physical, mental, and social health interventions (Zheng et al., 2023). The literature suggests the need for high-quality and effective holistic strategies aimed at enhancing psychological well-being in older adults.

Through our observations, we revealed the effectiveness of nonpharmacological interventions in improving sleep quality and addressing frailty in older adults, with promising but varied evidence across studies. For vitality, interventions combining nutrition and physical exercise have shown moderate effectiveness in reducing frailty indicators (J. Apóstolo et al., 2018; Racey et al., 2021). These findings are consistent with those of previous studies, which indicated that malnutrition (i.e., dysphagia, poor dental status, and unintentional weight loss) (Buhl et al., 2022), lower physical activity (Sobhani et al., 2022), and sufficient sleep (Chagas et al., 2023) are considered key factors in frailty. In terms of sleep, brief behavioral therapy for insomnia (Chen et al., 2023; McLaren et al., 2023) or listening to music (Chen et al., 2021) has been shown to significantly enhance sleep quality. has been shown to significantly enhance sleep quality. The findings align with those of previous studies supporting the effectiveness of cognitive—behavioral interventions for insomnia (Vaddepalli, 2024) and highlighting music's role in reducing arousal and promoting relaxation (Kuan et al., 2018). However, the low and very low quality of evidence underscores the need for high-quality studies to confirm these benefits and explore the mechanisms underlying these improvements.

On the basis of our findings, we did not identify effective sensory or continence interventions. The findings in the sensory domain, which specifically focused on environmental and behavioral interventions for older adults with irreversible visual impairment, indicated limited effectiveness in improving physical activity or reducing fall risk (E et al., 2020). These inconsistent findings could stem from the heterogeneity in participant characteristics, the intensity and duration of behavioral interventions and differences in environmental adaptations. Future research should focus on integrating more comprehensive, multimodal approaches that combine environmental modifications with tailored behavioral interventions and assistive technologies to address the unique needs of visually impaired older adults.

With respect to continence, we reviewed a similar article that discussed multifaceted self-management interventions for urinary incontinence in older women. These interventions included pelvic floor muscle exercises, bladder retraining, and a combination of behavioral interventions, which resulted in statistically significant improvements in incontinence symptoms. Importantly, the article specifically focused on women aged over 55 years who did not meet our inclusion criteria (Fu et al., 2019). Possible explanations for the lack of current review articles examining interventions to improve incontinence include the complexity of incontinence and measurement and reporting issues (Tran and Puckett, 2023). This complexity makes it challenging to develop a one-size-fits-all intervention that is universally effective. Moreover, incontinence outcomes are often self-reported, and many individuals with urinary incontinence may not actively seek help, introducing potential bias and variability in the data. Our study highlights the need for future research to focus on developing effective strategies and objective measures to address urinary incontinence to enhance IC in older individuals.

4.1. Limitations

The present review specifically focused on conducting a systematic review to identify comprehensive and effective strategies aimed at improving each component of IC in individuals aged 60 years and older. First, it is important to note that only a limited number of studies have specifically addressed subdomains such as sensory function and urinary continence. This paucity of studies may result in an underestimation of the effects within the scope of the review. Second, the inclusion of articles that integrated diverse interventions and populations presents a challenge in obtaining precise results from our review. Finally, it is worth noting that all the studies included in our analysis focused on community-dwelling older adults with comorbid conditions. As a result, the sample may not be representative of all older adults across different environments.

4.2. Strengths and implications

This study has several strengths that advance the field of IC research and intervention strategies for older adults. First, as an umbrella review, it consolidates evidence from multiple SRMAs, providing a comprehensive overview of the effectiveness of nonpharmacological interventions across multiple IC domains. This approach helps address inconsistencies in previous findings and highlights areas where high-quality evidence exists, such as mobility interventions, and where it remains limited, as in the sensory and continence domains. Second, by analyzing studies on community-dwelling older adults, this review emphasizes real-world settings, making the findings particularly relevant for implementing IC-enhancing strategies in community and outpatient contexts. Third, the inclusion of a broad range of IC domains allows for a holistic understanding of how various nonpharmacological interventions may collectively contribute to healthy aging.

In terms of implications, this study provides valuable guidance for future research and clinical practice. For researchers, the findings underscore the need for high-quality trials focusing on IC as a whole, such as sensory and continence functions, to develop a more balanced and comprehensive evidence base. Additionally, the identification of promising intervention areas can inform the design of targeted studies to refine and validate specific IC-enhancing strategies. For practitioners, the review highlights effective approaches to promote IC, such as mobility training, cognitive exercises, music therapy, and multicomponent nutrition trials, encouraging their integration into routine care for older adults. Ultimately, this study underscores the importance of a holistic approach to IC, advocating for evidence-based, nonpharmacological interventions that can promote well-being in the aging population.

5. Conclusions

The effectiveness of nonpharmacological interventions in enhancing IC across different domains for older adults varies. There is sufficient evidence to support the majority of evidence focusing on the locomotor, cognitive, and psychological domains. However, in terms of sensory interventions, the limited number of studies have not provided high-quality evidence to confirm intervention effectiveness. Additionally, evidence to support the effectiveness of any specific strategy for managing urinary incontinence in older adults is insufficient. Our study suggests the need for further research to focus on developing effective strategies to address the issues of sleep, sensory function, and urinary

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incontinence to enhance IC in older individuals.

CRediT authorship contribution statement

The contributions of each author to this manuscript are listed below: YT Lo, HC Su, TW Liao, CH Liu, YL Wu, YC Yang, and YC Chen were responsible for the study design. YT Lo, HC Su, CC, TW Liao, CH Liu, YL Wu, SH Tam, CW Chou, YC Yang, YH Chen, and YC Chen completed the data analysis and manuscript preparation. YT Lo, HC Su, CC, TW Liao, CH Liu, YL Wu, SH Tam, CW Chou, YC Yang, YH Chen, and YC Chen approved the final manuscript.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) did not use any AI-assisted technologies.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Yen-Chin Chen reports financial support was provided by Ministry of Science and Technology. Yen-Chin Chen reports a relationship with The Ministry of Science and Technology that includes: funding grants and non-financial support. Yi-Ching Yang reports a relationship with National Health Research Institute that includes: funding grants. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.arr.2025.102742.

Data Availability

Data will be made available on request.

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