Review Article

A Scoping Review of Nonpharmacological Interventions to Reduce Disability in Older Adults

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Abstract

Background and Objectives: Minimizing disability is critical to reduce the costly health care associated with disability and maintain quality of life into old age. We examined the effect sizes of nonpharmacological intervention studies in reducing disability and explored the active ingredients of interventions.
Research Design and Methods: A scoping review was conducted via PubMed, PsycINFO, and CINAHL databases. Thirty-one randomized controlled trials were included. Eight active ingredients were identified by three experts (exercise, problem-solving, cognitive behavioral therapy, environmental modification, education, goal setting, comprehensive geriatric assessment, and cognitive training).
Results: The range of Cohen's d was –0.85 to 1.76 across 31 studies (included 33 interventions); 67% studies (n = 22) obtained small-to-negative effect sizes (d = –0.85 to 0.18), accounting for 83% participants across studies. Interventions that incorporated exercise, problem-solving, cognitive behavior therapy, and environmental modification were associated with stronger effect sizes. Interventions that incorporated comprehensive geriatric assessment obtained small effect sizes.
Discussion and Implications: Majority of intervention studies found little or no effect in reducing disability for older adults. To optimize the effects of nonpharmacological interventions, we recommend researchers to (i) develop a screening tool for "risk of disability" to inform those who are early on the disability progression, yet not experience any difficulties in activities of daily living and instrumental activities of daily living; (ii) specify the active ingredients embedded in complex interventions to facilitate change in disability; and (iii) select sensitive tools to capture the progression of disability in late life.

Keywords: Intervention efficacy, Active ingredients, Complex interventions

One of three older adults experiences disability. Disability is defined by the inability to sustain independence with basic activities of daily living (ADL) or instrumental activities of daily living (IADL; Kraus, 2017; Ortman, Velkoff, & Hogan, 2014). ADL and IADL disabilities are associated with substantial health care costs; older adults with disability have greater out-of-pocket health care expenditures than older adults without disability (Mitra, Palmer, Kim, Mont,

& Groce, 2017). Older adults with disability also experience a lower sense of well-being (Groessl et al., 2007). Effective strategies to minimize disability become critical to reduce costly health care related to disability and sustain quality of life into old age.

Nonpharmacological interventions are promising to reduce disability in late life. They adopt behavioral change techniques, devices, and technologies to facilitate change in health and quality of life (Boutron, Moher, Altman, Schulz, & Ravaud, 2008). They may include complementary and alternative medicine and therapy (e.g., Tai Chi). As such, they often have fewer risks and side effects than pharmacological interventions (Krishnan et al., 2018). Typically, they are developed for older adults with a single medical condition, once disability has emerged. For example, moderate-intensity, supervised exercise programs have been developed to improve function after acute myocardial infarction or cardiac arrest (Boyce et al., 2017; Peixoto et al., 2015). Although these nonpharmacological interventions have demonstrated success in reducing disability, intervening after the emergence of medical conditions is often too late to minimize disability because the acute medical condition already results in newly acquired disability (Capistrant et al., 2014). In addition, after acute medical conditions, these illnesses often have exacerbations or remissions that lead to risks of comorbidity and long-term disability (Brown et al., 2009; Collins et al., 2018).

Instead of focusing on a single medical condition or comorbidity, researchers have adopted various eligibility criteria (e.g., frailty or at-risk of falling) to examine how to minimize disability through nonpharmacological interventions for broader groups of older adults (Ferrucci et al., 2004). Older adults who fit these criteria may have disability that is not caused by an acute medical condition, but they have a higher risk for acquiring more severe disability, as describe by Ferrucci and colleagues. Little research has examined how effective these nonpharmacological interventions are at minimizing disability for older adults that fit these eligibility criteria.

In addition, the active ingredients that drive the efficacy of nonpharmacological interventions are poorly specified and evaluated (Boutron et al., 2008). Active ingredients are the key components that are embedded in the interventions to change outcomes. Nonpharmacological interventions are often complex interventions, as defined by the Medical Research Council (Craig et al., 2008). A complex intervention is composed of more than one active ingredient (Michie, Fixsen, Grimshaw, & Eccles, 2009). These active ingredients can be problem-solving, goal setting, exercise, or comprehensive geriatric assessment (Michie et al., 2013; Wells, Seabrook, Stolee, Borrie, & Knoefel, 2003). The evaluation of active ingredients is critical because they may determine intervention efficacy in reducing disability in late life.

The purpose of this scoping review was to examine the effects of nonpharmacological interventions on disability in community-dwelling older adults participating in randomized controlled trials. The active ingredients of the interventions were also examined. We chose to include studies that recruited community-dwelling older adults to inform the development of future home-based programs. Information gleaned from this review may provide insights into how to optimize the effects of nonpharmacological interventions on disability for older adults.

Methods

Identifying Relevant Studies

We followed the scoping review methodological approach (Arksey & O'Malley, 2005; Moher, Liberati, Tetzlaff, & Altman, 2009). An electronic search was conducted in January 2018 of PubMed, PsycINFO, and CINAHL databases to locate intervention studies (without date restrictions on the publications). The terms used for the literature search were older adults, disability, preclinical disability, activities of daily living, instrumental activities of daily living, intervention, social engagement, social participation, treatment outcome, clinical trial, and clinical study. Terms were paired to search for eligible studies.

Study Selection

We included studies that (i) recruited community-dwelling older adults aged at least 50 years, (ii) examined nonpharmacological interventions via randomized controlled trials (without the use of medication or substances), (iii) measured ADL or IADL disabilities as primary or secondary outcomes, (iv) included at least one follow-up, (v) were written in English, and (vi) had sufficient data to calculate effect sizes. We excluded interventions that (i) focused on a specific diagnosis (e.g., cardiac arrest), (ii) focused on one gender; (iii) were not home based, and (iv) had follow-up longer than 3 years to minimize the influence of follow-up duration on results. Mendeley software (version 1.17) was used to manage the selection process (Mendeley Ltd, 2017). The preferred reporting items for systematic review and meta-analysis guidelines were followed (Supplementary Appendix A; Moher et al., 2009).

A two-level screening process was performed to determine the inclusion eligibility: (i) title and abstract review and (ii) full-text review. One reviewer (C. Y. W) reviewed abstracts and titles. Discrepancies in eligibility were determined through consensus by three authors (J. R., E. R. S., and C. Y. W.).

Charting the Data

Study characteristics (number of participants, age, gender, dosage, intervention session format, measure of disability, and follow-up duration) and the means and standard deviations of disability were extracted for intervention and control groups. Baseline disability was categorized into

four levels (negligible, mild, moderate, and severe) using the cutoff points of measures of disability listed in the studies.

Active ingredients of interventions were identified and coded based on the descriptions of interventions within the articles. Three independent authors coded the active ingredients separately (J. R., E. R. S., and C. Y. W.). Discrepancies were discussed and resolved by three authors (J. R., E. R. S., and C. Y. W.). Complex intervention (YES/NO) was characterized by more than one included active ingredient (Craig et al., 2008).

Collating, Summarizing, and Reporting the Results

Effect sizes were computed using standardized mean differences, as known as Cohen's *d*. The Cohen's *d* was estimated by the differences between the mean changes of disability in the intervention and control groups divided by the pooled standard deviation (*SD*) of disability at baseline (Feingold, 2009). The effect sizes of the primary outcome were selected if multiple assessments were used to measure disability. The effect size of the longest follow-up was selected if there were multiple follow-ups.

STATA (version 15.0; StataCorp, 2017) and SPSS (version 24.0; IBM Corp., 2013) were used for statistical analyses. For each active ingredient, the heterogeneity of included studies was computed using the *I*-square statistics (I^2; Higgins & Thompson, 2002). The magnitude of heterogeneity was followed by low (30%), moderate (50%), and high (75%). All the analyses were considered significant at the .05 two-tailed α level.

Cohen's *d* was used to categorize the four-level magnitude of effect sizes (<0.2 = *negligible*; 0.2–0.5 = *small*; 0.5–0.8 = *moderate*; >0.8 = *large*; Lakens, 2013). We calculated the proportion of participants within each magnitude of effect size (negligible, small, moderate, and large) across active ingredients. The greater proportion of participants in the studies with moderate-to-large effect sizes, the more influence of an active ingredient on disability. This approach provided a visualization of magnitudes of effect sizes across studies, accounting for study sample sizes. Forest plots were generated for each active ingredient to visualize and synthesize the effect sizes of studies.

Results

Study Characteristics

A total of 2,385 articles were identified; 363 articles were reviewed by full text. A total of 49 articles were eligible for this review (Figure 1). Sixteen authors were contacted and requested to provide means and *SD*s for studies that did not include necessary data. Means and *SD*s were obtained from two authors. There were 31 studies (included 33 interventions) with sufficient data (i.e., means and *SD*s) to be included in the analyses (Table 1; Figure 2; Supplementary Appendix B).

A quarter of the studies (25.8%) had longer than 12-month follow-up. Nearly three-fourths studies (74.2%) listed disability as their primary outcome. Almost half of the studies (47.2%) examined complex interventions. Most of the studies (80.6%) had individual sessions in the interventions as opposed to group sessions. Intervention dosages varied from 2 to 78 sessions (3 sessions per week for 26 weeks).

Eleven measurements were used to assess disability (Table 1). Several authors developed participant-reported measures of disability (*n* = 7). Barthel Index (*n* = 5; Mahoney & Barthel, 1965) and Nottingham Extended Activities of Daily Living Scale (*n* = 4; Nouri & Lincoln, 1987) were the most frequently used tools to assess ADL and IADL disabilities. Other studies used Groningen Activity Restriction Scale (*n* = 3; Kempen & Suurmeijer, 1990), Functional Status Questionnaire (*n* = 3; Jette et al., 1986), Frenchay Activities Index (*n* = 2; Schuling, de Haan, Limburg, & Groenier, 1993), or Lawton IADL measures (*n* = 2; Lawton & Brody, 1969).

Participant Characteristics

Studies recruited participants with negligible (*n* = 9), mild (*n* = 11), moderate (*n* = 12), and severe disability (*n* = 1; Figure 2).

Effects of Intervention Studies

There was a moderate-to-high heterogeneity among the 31 studies (I^2= 73.5%, *p* < .001). Figure 2 illustrates the effect size *d* ranged from –0.85 to 1.76 across studies, with 9 having statistically significant effect sizes (Alexopoulos et al., 2011; Binder et al., 2002; Callahan et al., 2005; Foley, Hillier, & Barnard, 2011; Gill et al., 2004; Kerse et al., 2014; Szanton et al., 2011; Villareal, Banks, Sinacore, Siener, & Klein, 2006; von Bonsdorff et al., 2008). Of the 31 studies, 22 had negligible effect sizes, accounting for 83% of total participants; 6 studies had mild effect sizes, accounting for 14% of total participants; 3 studies had moderate effect sizes, accounting for 2% of total participants; and 2 studies had large effect sizes, accounting for 1% of total participants. Studies included measures of ADL disability, IADL disability, and ADL-combined IADL disability. These effect size ranged from *d* = –0.62 to 1.76, *d* = –0.09 to 0.69, and *d* = –0.85 to 0.88, respectively.

Effects of Active Ingredients Embedded in the Interventions

Table 2–3 shows eight active ingredients that were identified and defined as exercise, problem-solving, cognitive behavioral therapy, environmental modification, education, goal setting, comprehensive geriatric assessment, and cognitive training.

Table 1. Included Studies (*n* = 31)

Authors, (year)	Population	No. allocated		Mean age (year)		Female (%)		Dosage	Session format	Disability measure	Primary outcome (Yes; No)	Follow-up duration (month)
		Intervention	Control	Intervention	Control	Intervention	Control					
Alexopoulos et al. (2011)	Major depressive disorder	110	111	72.8	73.2	N/A	N/A	12 Weekly sessions	Individual	WHODAS	Yes	9
Binder et al. (2002)	Frailty	66	49	83.0	83.0	52.0	53.0	1 h/3 times × 12 weeks	Group	FSQ	Yes	9
Bouman et al. (2008)	Poor health conditions	139	154	75.8	75.6	60.0	60.0	1–1.5 h/8 sessions	Individual	GARS	Yes	24
Callahan et al. (2005)	Major depression or dysthymic disorder	906	895	71.0	71.4	64.1	65.6	6–8 Sessions	Individual	7 IADL	Yes	12
Cameron et al. (2013)	Frailty	108	116	83.4	83.2	67.0	68.0	10 Sessions	Individual	BI	Yes	12
Chin et al. (2001)	Physical inactivity	80	74	77.5	78.9	73.0	70.0	45 min/2 times × 17 weeks	Group	16 ADL	Yes	3
Clare et al. (2015)	Without dementia or intellectual disability	22 / 21	27 / 27	68.2 / 67.5	70.2 / 70.2	79.2 / 95.8	85.2 / 85.2	A session and a follow-up call	Individual	FCAS	Yes	12
Clark et al. (1997)	Without dementia	101	202	N/A	N/A	64.0	65.5	2 h per week/9 month	Group+Individual	FSQ	Yes	9
Counsell et al. (2007)	Income less than 200% of the federal poverty level	474	477	71.8	71.6	75.5	76.5	1 Visit and 1 phone call	Individual	7 ADL + 6 BADL	Yes	24
Day et al. (2012)	Preclinical disability	171	190	N/A	N/A	66.2	69.7	1 h/2 times × 48 weeks	Group	LLFDI	Yes	6
Dorresteijn et al. (2016)	Concerns about falls and associated activity avoidance	141	171	78.4	78.3	68.0	72.3	3 Sessions; 4 phone calls	Individual	GARS	No	12
Fairhall et al. (2012)	Frailty	111	121	83.4	83.2	67.0	68.0	1 h/10 sessions	Individual	LSA-UAB	Yes	12
Foley et al. (2011)	Discharge from day rehabilitation	34	36	78.3	79.9	79.0	81.0	1 h/24 sessions	Individual	BI	Yes	3
Gill et al. (2004)	Frailty	91	91	82.8	83.5	85.0	74.0	16 Sessions × 6 months	Individual	8 ADL	Yes	12
Gitlin et al. (2006)	Difficulty with two IADLs or one ADL	154	146	79.5	78.5	82.5	81.1	1.5 h/6 sessions	Individual	6 ADL + 6 IADL	Yes	12
Haines et al. (2009)	Discharged from hospital	19	34	80.9	80.5	74.0	53.0	8 Weekly phone calls	Individual	FAI	Yes	6
Hendriks et al. (2008)	Fall	123	134	74.5	75.2	66.9	70.1	2 Visits	Individual	FAI	No	12

Table 1. Continued

Authors, (year)	Population	No. allocated		Mean age (year)		Female (%)		Dosage	Session format	Disability measure	Primary outcome (Yes; No)	Follow-up duration (month)
		Intervention	Control	Intervention	Control	Intervention	Control					
Kerse et al. (2010)	Depressive symptoms	94	87	81.4	80.8	63.9	53.1	1 h/8 sessions	Individual	NEADL	Yes	12
Kerse et al. (2014)	Participated in primary care practice	1787	1619	80.4	80.3	56.0	54.0	3 Visits	Individual	NEADL	Yes	36
King et al. (2012)	Received assistance from the home care	82	82	80.5	78.4	77.4	69.9	At least 5 visits	Individual	NEADL	No	7
Kono et al. (2012)	Frailty	105	100	80.3	79.6	73.9	74.1	4 Visits	Individual	BI	Yes	24
Lannin et al. (2007)	Mild to no cognitive impairments	5	5	80.0	82.4	100	60.0	55–85 min/1 session	Individual	NEADL	Yes	3
Liu et al. (2014)	Fall	64	58	74.5	74.5	87.5	86.2	1.5 h/8 sessions	Group	5 Social activities	No	3
Mahoney et al. (2007)	Fall	130	135	79.6	80.3	78.7	78.3	2 Visits/phone calls	Individual	BI	No	12
Pighills et al. (2011)	Fall	87 73	78 78	78.0 79.0	80.0 80.0	71.0 62.0	67.0 67.0	1 Visit/2 phone calls	Individual	BI	No	12
Rockwood et al. (2003)	Frailty	85	80	81.4	82.2	56.8	57.5	1–6 Visits/1 follow-up	Individual	Lawton IADL	N/A	12
Rydwik et al. (2010)	Frailty	20	19	83.5	82.9	47.8	69.6	1 h/2 times × 12 weeks	Group	FIM	No	24
Szanton et al. (2011)	Low income; difficulties in 1 ADL or 2 IADLs	20	15	79.0	77.0	96.0	94.0	1 h/10 sessions	Individual	5 ADL + 6 IADL	Yes	6
van Hout et al. (2010)	Frailty	331	330	81.3	81.5	72.2	68.8	3 Visits/phone contacts	Individual	GARS	Yes	18
Villareal et al. (2006)	Frail and obese	17	10	71.1	69.4	60.0	71.0	1.5 h/3 days × 26 weeks	Group	FSQ	Yes	24
von Bonsdorff et al. (2008)	Sedentary	310	306	77.6	77.6	74.5	75.2	1 h/every 4 months phone calls	Individual	Lawton IADL	Yes	24
Total		6081	5952	77.9	78.4	71.8	69.7					

Note: N/A = none applicable; WHODAS = World Health Organization Disability Assessment Schedule; FSQ = Functional Status Questionnaire; GARS = Groningen Activity Restriction Scale; BI = Barthel Index; FCAS = Florida Cognitive Activities Scale; LLFDI = Late-Life Function and Disability Instrument; LSA-UAB = University of Alabama at Birmingham Study of Aging Life-Space Assessment; FAI = Frenchay Activities Index; NEADL = Nottingham Extended Activities of Daily Living Scale; FIM = Functional Independence Measure.
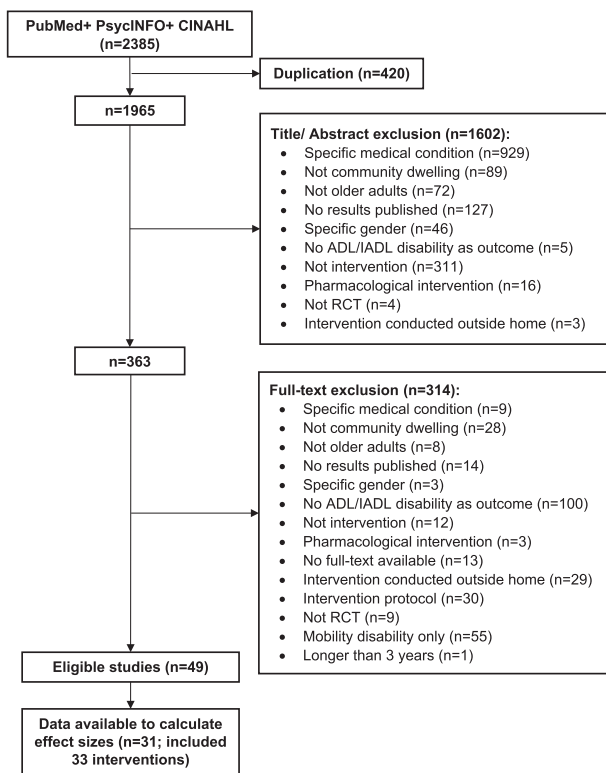
Figure 1. Review diagram.

Exercise

Exercise was an active ingredient of 13 interventions in 13 studies (Binder et al., 2002; Cameron et al., 2013; Chin A Paw, de Jong, Schouten, Hiddink, & Kok, 2001; Day et al., 2012; Dorresteijn et al., 2016; Fairhall et al., 2012; Foley et al., 2011; Gill et al., 2004; Gitlin et al., 2006; Haines et al., 2009; Kerse et al., 2010; Rydwik, Frandin, & Akner, 2010; Villareal et al., 2006; Table 3; Supplementary Appendix C). There was high heterogeneity among the 13 studies ($I^2 = 86.6\%$, $p < .001$). The effect size d ranged from –0.85 to 1.76 across studies, with four studies having statistically significant effect sizes (Binder et al., 2002; Foley et al., 2011; Gill et al., 2004; Villareal et al., 2006). Exercise programs focused on aerobic training, resistance training, balance, or Tai-Chi. Foley and colleagues conducted an aerobic exercise program for older adults with musculoskeletal impairments, surgeries, or falls. Results showed a large, statistically significant effect size ($d = 1.76$). Villareal and colleagues engaged older adults in flexibility, endurance, strength, and balance training. They found a large effect size ($d = 0.88$; baseline to 26 months). Gill and colleagues trained older adults in bed transfer, indoor, and outdoor mobility. Results demonstrated a small-to-moderate effect size ($d = 0.39$; baseline to 12 months). There were negative effect sizes in favor of the control groups over time in the studies of Chin and colleagues.

Problem-solving

Problem-solving was an active ingredient of nine interventions in eight studies (Alexopoulos et al., 2011;

Callahan et al., 2005; Clare et al., 2015; Dorresteijn et al., 2016; Gitlin et al., 2006; Szanton et al., 2011; Villareal et al., 2006; von Bonsdorff et al., 2008; Table 3; Supplementary Appendix D). There was no statistically significant heterogeneity among the eight studies ($I^2 = 0.0\%$, $p = .72$). Effect size d ranged from 0.21 to 0.88 across studies, with five studies having statistically significant effect sizes (Alexopoulos et al., 2011; Callahan et al., 2005; Szanton et al., 2011; Villareal et al., 2006; von Bonsdorff et al., 2008). Alexopoulos and colleagues and Callahan and colleagues used problem-solving therapy to reduce disability for older adults with depressive symptoms. Alexopoulos and colleagues found a significant group difference in change in disability ($d = 0.28$; baseline to 36 weeks), but Callahan and colleagues did not find a significant group difference ($d = 0.17$; baseline to 12 months). Villareal and colleagues applied problem-solving skills to modify eating habits and lifestyles in older adults who were obese. Results showed a large effect size ($d = 0.88$; baseline to 6 months). Szanton and colleagues used problem-solving techniques to resolve behavioral and environmental barriers for older adults. They found a moderate effect size ($d = 0.69$; baseline to 6 months).

Cognitive behavioral therapy

Cognitive behavioral therapy was an active ingredient of eight interventions in seven studies (Alexopoulos et al., 2011; Callahan et al., 2005; Clare et al., 2015; Dorresteijn et al., 2016; Liu & Tsui, 2014; Villareal et al., 2006; von Bonsdorff et al., 2008; Table 3; Supplementary Appendix E). There was no statistically significant heterogeneity among the seven studies ($I^2 = 0.0\%$, $p = .60$). The effect size d ranged from –0.06 to 0.88 across studies, with four studies having statistically significant effect sizes (Alexopoulos et al., 2011; Callahan et al., 2005; Villareal et al., 2006; von Bonsdorff et al., 2008). Two interventions incorporated cognitive behavioral therapy to reduce the fear of falling and promote reengagement in ADL for older adults (Dorresteijn et al., 2016; Liu & Tsui, 2014). Zijlstra and colleagues (2009) and Dorresteijn and colleagues (2016) together developed "A Matter of Balance-Netherlands program" for frail older adults. Results showed that the intervention group had more reductions in disabilities compared with the usual-care control ($d = 0.21$; baseline to 12 months). Liu and colleagues incorporated cognitive behavioral techniques to reduce the fear of falling. Results showed a negative effect size ($d = –0.06$). Alexopoulos and colleagues and Callahan and colleagues incorporated cognitive behavioral techniques to change older adults' distorted thoughts (e.g., outdoor activities will make me fall). Both studies found small-to-moderate effect sizes ($d = 0.28$; 0.17). Villareal and colleagues recruited frail older adults and adopted cognitive behavioral therapy to change diets, exercise, and functional status. Results showed a high magnitude effect size ($d = 0.88$).

Environmental modification

Environmental modification was an active ingredient of four interventions in four studies (Gill et al., 2004; Gitlin et al., 2006; Mahoney et al., 2007; Szanton et al., 2011; Table 3; Supplementary Appendix F). There was negligible heterogeneity among the four studies ($I^2 = 26.2\%$, $p = .25$). The effect size d ranged from 0.10 to 0.69 across studies, with two studies having statistically significant effect sizes (Gill et al., 2004; Szanton et al., 2011). Environmental modification usually involved (i) assessing environmental hazards, (ii) removing environmental hazards, (iii) installing equipment. Gitlin and colleagues and Szanton and colleagues designed environmental modification interventions to reduce disability for low-income older adults with mild disabilities. Szanton and colleagues

found a significant group difference in change in disability ($d = 0.69$; baseline to 6 months), but a nonsignificant group difference in the study of Gitlin and colleagues ($d = 0.21$). Gill and colleagues had physical therapists evaluate the home environment and provide recommendations to remove cords, replace mats, and install adaptive equipment. Results showed a group difference in change in disability ($d = 0.39$; baseline to 12 months).

Education

Education was an active ingredient of 10 interventions in 10 studies (Callahan et al., 2005; Clark et al., 1997; Dorresteijn et al., 2016; Gill et al., 2004; Gitlin et al., 2006; King, Parsons, Robinson, & Jorgensen, 2012; Lannin et al., 2007; Mahoney et al., 2007; Szanton et al.,

Table 2. Definitions of Active Ingredients

Active ingredient	Definition	Keywords
Exercise	Strengthen physical function, body structure, and physiological reserves	Exercise; physical activity; strengthening; walk; physical training; Tai-Chi; balance; mobility; agility; stretching
Problem-solving	Identify problems in daily activities, propose solutions to solve the problems, and implement solutions	Problem-solving; action plan; review solutions; identify strategies; refine strategies; design a plan; mutual problem-solving; overcome barriers; propose ways
Cognitive behavioral therapy	Discuss and identify patterns of thinking or behaviors. Change distorted thoughts to change behaviors and mood	Cognitive behavioral therapy; cognitive behavioral interventions
Environmental modification	Modify environmental factors, such as home, light, rug, and handrail	Environmental modification; eliminate environmental hazards; home modification
Education	Deliver, shape, or instruct knowledge on how to perform a behavior or deal with situations	Education; impart knowledge; didactic teaching; educational videotape
Goal setting	Identify goals that are relevant to health professionals or participants	Goal setting; preview goals; identify goals; prioritize goals; set realistic goals
Comprehensive geriatric assessment	A therapeutic process that incorporated medical, psychosocial or functional assessments to inform care plans for primary care teams and rehabilitation fields	Comprehensive geriatric assessment; multidimensional geriatric instrument; standardized health assessment
Cognitive training	Train specific cognitive domains, including processing speed, memory, attention, or reasoning	Cognition training; mathematics; attention memory; visuospatial ability; processing speed; reasoning; visual search skill

Table 3. Effect Sizes of Active Ingredients

Intervention characteristics	No. of studies	No. of sample	I^2	Range of effect size d	Four-level magnitude of effect sizes[a]			
					<0.2 Negligible	0.2-0.5 Small	0.5-0.8 Moderate	>0.8 Large
Active ingredient								
Exercise	13	2214	86.6%*	−0.85–1.76	55%	36%	5%	4%
Problem-solving	8	3418	0.0%	0.17–0.88	54%	44%		
CBT	8	3196	0.0%	−0.06–0.88	62%	37%		
Environmental modification	4	778	26.2%	0.10–0.69	34%	61%	4%	
Education	10	3361	0.0%	0.02–0.69	75%	24%		
Goal setting	9	2983	18.8%	−0.09–0.88	78%	20%	2%	
CGA	15	6892	0.0%	−0.09–0.69	94%		3%	3%
Complex intervention	15	4603	0.0%	−0.09–0.88	62%	36%		
Total	31	12033	73.5%*	−0.85–1.76	83%	14%	2%	1%

Note: CBT = cognitive behavioral therapy; CGA = comprehensive geriatric assessment. *Statistically significant ($p < .05$).
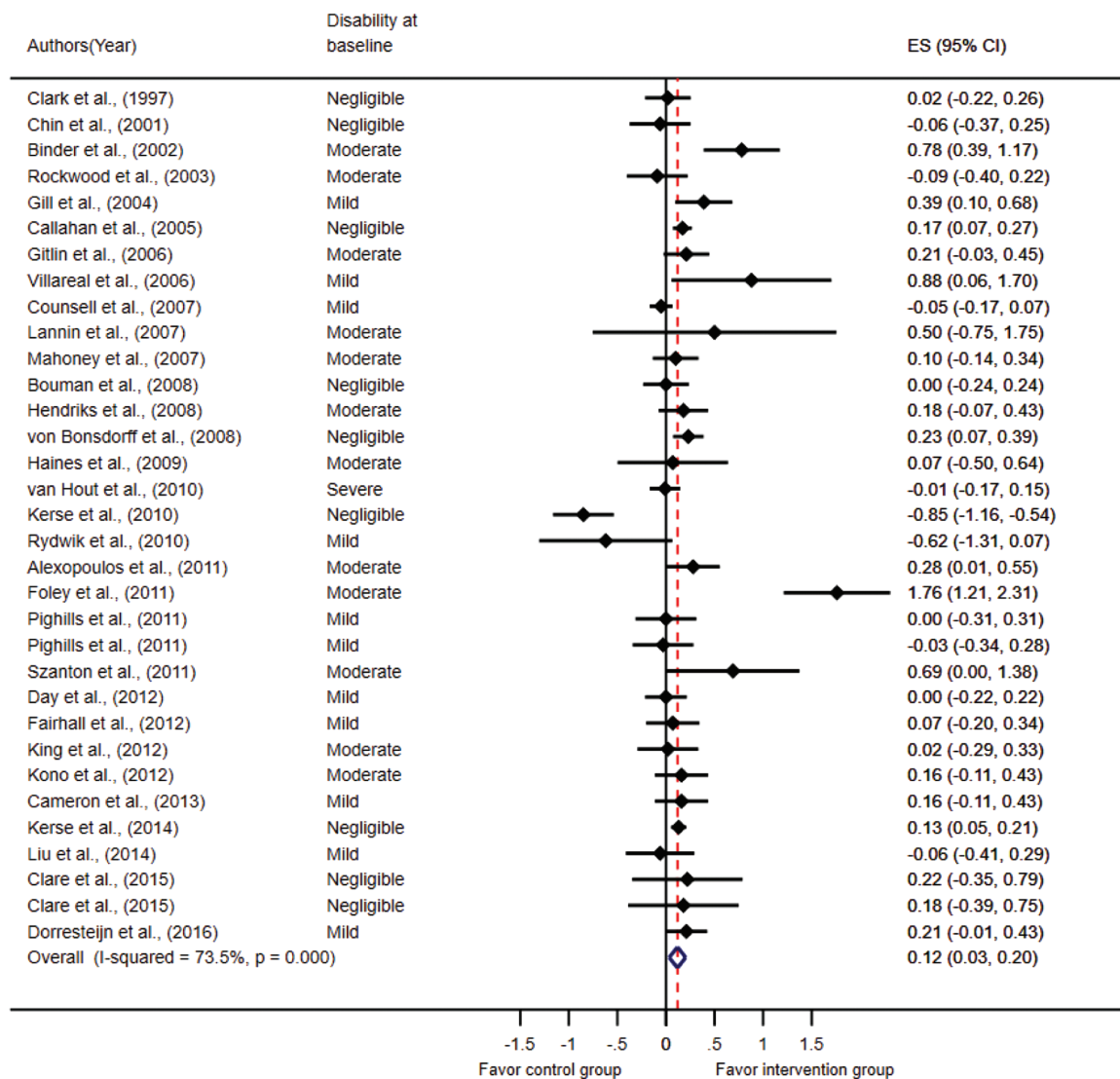[a]The proportions accounted for numbers of participants.

Authors(Year)	Disability at baseline	ES (95% CI)
Clark et al., (1997)	Negligible	0.02 (-0.22, 0.26)
Chin et al., (2001)	Negligible	-0.06 (-0.37, 0.25)
Binder et al., (2002)	Moderate	0.78 (0.39, 1.17)
Rockwood et al., (2003)	Moderate	-0.09 (-0.40, 0.22)
Gill et al., (2004)	Mild	0.39 (0.10, 0.68)
Callahan et al., (2005)	Negligible	0.17 (0.07, 0.27)
Gitlin et al., (2006)	Moderate	0.21 (-0.03, 0.45)
Villareal et al., (2006)	Mild	0.88 (0.06, 1.70)
Counsell et al., (2007)	Mild	-0.05 (-0.17, 0.07)
Lannin et al., (2007)	Moderate	0.50 (-0.75, 1.75)
Mahoney et al., (2007)	Moderate	0.10 (-0.14, 0.34)
Bouman et al., (2008)	Negligible	0.00 (-0.24, 0.24)
Hendriks et al., (2008)	Moderate	0.18 (-0.07, 0.43)
von Bonsdorff et al., (2008)	Negligible	0.23 (0.07, 0.39)
Haines et al., (2009)	Moderate	0.07 (-0.50, 0.64)
van Hout et al., (2010)	Severe	-0.01 (-0.17, 0.15)
Kerse et al., (2010)	Negligible	-0.85 (-1.16, -0.54)
Rydwik et al., (2010)	Mild	-0.62 (-1.31, 0.07)
Alexopoulos et al., (2011)	Moderate	0.28 (0.01, 0.55)
Foley et al., (2011)	Moderate	1.76 (1.21, 2.31)
Pighills et al., (2011)	Mild	0.00 (-0.31, 0.31)
Pighills et al., (2011)	Mild	-0.03 (-0.34, 0.28)
Szanton et al., (2011)	Moderate	0.69 (0.00, 1.38)
Day et al., (2012)	Mild	0.00 (-0.22, 0.22)
Fairhall et al., (2012)	Mild	0.07 (-0.20, 0.34)
King et al., (2012)	Moderate	0.02 (-0.29, 0.33)
Kono et al., (2012)	Moderate	0.16 (-0.11, 0.43)
Cameron et al., (2013)	Mild	0.16 (-0.11, 0.43)
Kerse et al., (2014)	Negligible	0.13 (0.05, 0.21)
Liu et al., (2014)	Mild	-0.06 (-0.41, 0.29)
Clare et al., (2015)	Negligible	0.22 (-0.35, 0.79)
Clare et al., (2015)	Negligible	0.18 (-0.39, 0.75)
Dorresteijn et al., (2016)	Mild	0.21 (-0.01, 0.43)
Overall (I-squared = 73.5%, p = 0.000)		0.12 (0.03, 0.20)

-1.5   -1   -.5   0   .5   1   1.5
Favor control group   Favor intervention group

Figure 2. A forest plot of the effects of 33 interventions on disability.

2011; von Bonsdorff et al., 2008; Table 3; Supplementary Appendix G). There was no statistically significant heterogeneity among the 10 studies ($I^2 = 0.0\%$, $p = .52$). The effect size d ranged from 0.02 to 0.69 across studies, with four having statistically significant effect sizes (Callahan et al., 2005; Gill et al., 2004; Szanton et al., 2011; von Bonsdorff et al., 2008). Education programs incorporated diverse modalities, including educational videotape, booklet, volunteer lecture, or homework. Three studies provided education on exercise (Gill et al., 2004; Mahoney et al., 2007; von Bonsdorff et al., 2008). Exercise programs of von Bonsdorff and colleagues and Gill and colleagues found small-to-moderate effect sizes ($d = 0.23$; 0.39), but a nonsignificant effect size was observed in the program of Mahoney and colleagues ($d = 0.10$). Callahan and colleagues provided educational videotapes for older adults with depressive symptoms. The intervention group reduced more disability than

the control group ($d = 0.17$; baseline to 12 months). Lannin and colleagues educated older adults on safety precautions for performing ADL. Results showed a nonsignificant moderate effect size ($d = 0.50$; baseline to 3 months). Clark and colleagues applied the didactic teaching method to help older adults select healthy lifestyles. They found no group difference in change in disability ($d = 0.02$; baseline to 9 months).

Goal setting

Goal setting was an active ingredient of nine interventions in nine studies (Alexopoulos et al., 2011; Callahan et al., 2005; Clare et al., 2015; Dorresteijn et al., 2016; Fairhall et al., 2012; King et al., 2012; Rockwood et al., 2003; Szanton et al., 2011; Villareal et al., 2006; Table 3; Supplementary Appendix H). There was no statistically significant heterogeneity among the nine studies ($I^2 = 18.8\%$, $p = .28$). The effect size d ranged from –0.09

to 0.88 across studies, with four studies having statistically significant effect sizes (Alexopoulos et al., 2011; Callahan et al., 2005; Szanton et al., 2011; Villareal et al., 2006). Goals were described as either client-centered goals (e.g., go shopping myself; Alexopoulos et al., 2011; Callahan et al., 2005; Clare et al., 2015; Dorresteijn et al., 2016; Fairhall et al., 2012; Szanton et al., 2011; Villareal et al., 2006) or practitioner-centered goals (e.g., monitor blood sugar; King et al., 2012; Rockwood et al., 2003) across the nine included interventions. Three of seven client-centered goal setting interventions focused on physical activity goals (Dorresteijn et al., 2016; Fairhall et al., 2012; Villareal et al., 2006). Two of nine interventions used tools to facilitate goal-setting processes (Clare et al., 2015; Rockwood et al., 2003). Clare and colleagues used the Bangor Goal Setting Interview to guide participants in selecting five goals: physical activity, cognitive activity, physical health, diet, and social engagement. Results showed a nonsignificant, small effect size (d = 0.22; baseline to 12 months). Rockwood and colleagues used the Goal Attainment Scale to facilitate goal selection and scaling processes. They found a nonsignificant, negative effect size (d = –0.09; baseline to 3 months).

Comprehensive geriatric assessment
Comprehensive geriatric assessment was an active ingredient of 15 interventions in 15 studies (Bouman, van Rossum, Ambergen, Kempen, & Knipschild, 2008; Cameron et al., 2013; Counsell et al., 2007; Fairhall et al., 2012; Gill et al., 2004; Hendriks et al., 2008; Kerse et al., 2014; King et al., 2012; Kono et al., 2012; Mahoney et al., 2007; Pighills, Torgerson, Sheldon, Drummond, & Bland, 2011; Rockwood et al., 2003; Szanton et al., 2011; van Hout et al., 2010; Table 3; Supplementary Appendix I). There was negligible heterogeneity among the 15 studies (I^2 = 0%, p = .46). The effect size d ranged from –0.09 to 0.69 across studies, with three studies having statistically significant effect sizes (Gill et al., 2004; Kerse et al., 2014; Szanton et al., 2011). The comprehensive geriatric assessment was often defined as a therapeutic process that incorporated medical, psychosocial, or functional assessments to inform care plans for primary care teams and rehabilitation fields (Wells et al., 2003). The underlying premise was that via conducting comprehensive assessments, older adults' disability can be potentially reduced due to more awareness of health care providers and the development of care plans. Thus, the comprehensive geriatric assessment could be treated as an active ingredient that may lead to behavioral changes. Traditionally, older adults had less involvement in the development of care plans. Kerse and colleagues sent a yearly survey to participants to screen health conditions and triggered referrals to regional geriatrics assessment and rehabilitation services (d = 0.13). Counsell and colleagues used the comprehensive geriatric assessments to coordinate care by sharing results with primary care physicians to inform goal setting and implementation (d = –0.05). Gill and

colleagues' comprehensive geriatric assessment specifically assessed physical impairments and home environmental barriers (d = 0.39; baseline to 12 months). Szanton and colleagues involved participants in the care plans; they not only collected problematic ADL but interviewed environmental barriers that may impede behavioral changes (e.g., floor holes, uneven carpeting, lack of railings, and banisters). Results demonstrated a moderate-to-large effect size (d = 0.69; baseline to 6 months). Pighills and colleagues used the results of comprehensive geriatric assessments to provide recommendations for older adults, instead of primary care teams. They found a negative effect size in favor of the control group (d = –0.03).

Cognitive training
Cognitive training was an active ingredient of five interventions in three studies (Ball et al., 2002; Corbett et al., 2015; Ng et al., 2015). Data were insufficient to calculate effect sizes.

Complex Interventions
Fifteen interventions were complex interventions, as indicated by having more than one active ingredient in the intervention (Table 3; Supplementary Appendix J). There was no statistically significant heterogeneity among the 15 studies (I^2 = 0.0%, p = .54). The effect size d ranged from –0.09 to 0.88 across studies, with six studies having statistically significant effect sizes (Alexopoulos et al., 2011; Callahan et al., 2005; Gill et al., 2004; Szanton et al., 2011; Villareal et al., 2006; von Bonsdorff et al., 2008). The number of active ingredients in the complex interventions was as followed: 2 (n = 3; Cameron et al., 2013; Clare et al., 2015; Rockwood et al., 2003); 3 (n = 6; Alexopoulos et al., 2011; Clare et al., 2015; Fairhall et al., 2012; King et al., 2012; Mahoney et al., 2007; von Bonsdorff et al., 2008); 4 (n = 4; Callahan et al., 2005; Gill et al., 2004; Gitlin et al., 2006; Villareal et al., 2006); 5 (n = 2; Dorresteijn et al., 2016; Szanton et al., 2011).

Discussion
This review examined the science related to nonpharmacological intervention studies to reduce disability in community-dwelling older adults. The majority of included studies showed negligible-to-small effect sizes in minimizing disability. Yet, this finding may be argued to be clinically meaningful. For example, a small reduction of disability may slow down the progression toward severe disability and potentially reduce the cost of health care programs because health care expenditures are positively correlated with the severity of disability in aging population (Manton, Gu, & Lamb, 2006). Interventions that included exercise, problem-solving, cognitive behavioral therapy, and environmental modification as active ingredients were associated with stronger effect sizes in reducing disability.

We urge caution when interpreting this finding, given that the active ingredients were not mutually exclusive among interventions. The results may not be confirmatory until a systematic review in comparing active ingredients is completed. Altogether, these findings may inform future intervention strategies and priorities to reduce disability in late life.

Negligible-to-Small Effect Sizes Across Studies

There exist several possibilities to explain the negligible-to-small effect sizes across studies. The use of diverse eligibility criteria across studies resulted in a range of disability severity statuses among participants in the studies. Most of the included studies included older adults with negligible-to-moderate disability. As such, the effect sizes may not be as large as those interventions that aimed to reduce disability for older adults who have already developed severe disability. This explanation is based on the assumption that older adults with severe disability may have room to gain greater improvements than those with negligible or mild disability. Another explanation is our use of a conservative approach to calculate effect sizes, which has been suggested to generate conservative estimates (Feingold, 2009). Negligible-to-small effect sizes may result from the psychometric properties of measures of disability. A measurement with low sensitivity to change may fail to detect the true effects of intervention studies (Fok & Henry, 2015). Last, certain control groups (e.g., nutrition interventions) may have had some influence on disability rather than attention control groups, thus reducing the magnitude of effect sizes.

In addition, we found that the ranges of effect sizes varied from studies that focused on ADL, IADL, or ADL + IADL disabilities. Studies that focused on ADL disability had the widest range of effect sizes. Previous studies have suggested that ADL disability is more severe than IADL disability (Leibold, Holm, Raina, Reynolds III, & Rogers, 2014). Thus, studies focused on reducing ADL disability may result in more changes than IADL disability. Future studies that aim to reduce disability may provide the rationale of how interventions may change ADL and IADL disability.

The Effects of Active Ingredients on Disability

Many combinations of active ingredients were found in included interventions. The combination of problem-solving and environmental modification showed promise in reducing disability. This combination echoes current concept about the emergence of disability as a mismatch between personal strengths and environmental demands (World Health Organization, 2002). Problem-solving focuses on building individuals' problem-solving skills when facing barriers in ADL and IADL (D'Zurilla & Nezu, 2010), whereas environmental modification changed contexture factors to match individuals' needs (Petersson,

Lilja, Hammel, & Kottorp, 2008). The change of both personal and contextual factors helps older adults engage in ADL and IADL and thus, reduce disability.

Exercise showed promise in reducing disability, whereas comprehensive geriatric assessment found little or no effects on disability reduction. Interestingly, exercise and comprehensive geriatric assessment were often the only active ingredients in the interventions, comparing to goal setting and education that were often combined with other active ingredients. This suggests that active ingredients have different applicability and roles within interventions; and intervention effects are not determined by the number of active ingredients. Some active ingredients aim to initiate new behaviors, whereas others aim to maintain preferred behaviors (Wood, Quinn, & Kashy, 2002). How to combine the most effective active ingredients to reduce disability requires iterative case and pilot studies.

The mode of delivery can differ within the same active ingredient. For example, goal setting can be led by practitioners, older adults, or caregivers. In this review, we found that goals were mostly determined by practitioners, instead of older adults or caregivers. Because practitioner-selected goals may not always support an older adult autonomy and a family's expectation to change behaviors (Locke & Latham, 2002), future studies should separate those three perspectives while examining the effects of goal setting on disability.

Literature on comprehensive geriatric assessment has demonstrated its effectiveness for controlling disease progression and predicting mortality rates in late life (Stuck, Egger, Hammer, Minder, & Beck, 2002). Although our ultimate goal was to reduce disability, the involvement of older adults and family in the care plan processes following the comprehensive geriatric assessment becomes critical to empower older adults and caregivers to drive behavioral changes (Krishnan et al., 2017). However, in our review, some interventions that incorporated comprehensive geriatric assessment did not partner with older adults or their caregivers while making care plans. Thus, the potency of comprehensive geriatric assessment in reducing disability may not be as large as in controlling disease progression and mortality.

The Effects of Complex Interventions on Disability

The magnitudes of the effect sizes were not as large as we expected among studies that examined complex interventions. This may be due to a variety of possible reasons. First, complex interventions are "built up from more than one active ingredient, which may act both independently and interdependently. (p.455) (Campbell et al., 2007)" A clear understanding of how active ingredients work with each other is a critical step. However, the effects of active ingredients were rarely compared or even described in the complex interventions. For example, does the combination of goal setting with exercise reduce

more disability than the combination of goal setting with problem-solving? The unclarity of how active ingredients interact with each other has impeded the design of optimal and efficacious interventions. Second, complex interventions might be inadequately applied (insufficient dosages) in an inappropriate environment (homes vs community settings; Campbell et al., 2007; Craig et al., 2008).

Strengths and Limitations

This study provided valuable insights. First, this review included studies that recruited older adults from negligible-to-severe disability, but this disability was not caused by acute medical conditions. The strategy provided a way to capture older adults at-risk for severe disability. Second, the active ingredients in driving the efficacy of nonpharmacological interventions were explored. This information is critical to inform future intervention development and priorities. Third, disability was selected as the outcome, which is one of the top priorities to reduce the costly health care related to disability and sustain quality of life into old age.

The findings should be interpreted cautiously. First, the quality of studies was not evaluated, which may influence the potency of evidence. Second, research has shown that, often times, the active ingredients of nonpharmacological interventions were not well described in the contents of articles (Abraham & Michie, 2008). This limitation may impede the finding. Third, the adherence rates of interventions were not evaluated, which may influence the reported effects. The study dosage may influence the effects of interventions, especially to make behavioral changes. Last, there was considerable heterogeneity across 31 studies. These variances might contribute to eligibility criteria used in the studies, quality of interventions, and the selection of outcome measures.

Future Directions

Reducing disability among community-dwelling older adults relies on a clear understanding of problematic areas in their ADL and IADL. By comprehensively understanding these day-to-day activities, researchers can investigate the barriers older adults confront and further inform those who are at high risk of further disability.

Specifying and evaluating active ingredients in influencing intervention efficacy can provide valuable insights into why an intervention fails or succeeds, and how it can be optimized. For example, the multiphase optimization strategy identifies active ingredients within interventions and optimizes dosages of each active ingredient to refine complex interventions (Collins, Murphy, & Strecher, 2007). Future studies may adopt systematic protocols and methodologies to refine nonpharmacological interventions "prior to" the implementation phases. This, in turn, would help replication studies and support evidence-based practice.

The measurements that assess disability should obtain sensitivity to capture the change in older adults with minimal disability. Early decline in disability is usually silent and fluctuating. An assessment that captures change in disability for older adults must assess the quality of their performance in ADL and IADL (Freedman et al., 2014).

In summary, nonpharmacological interventions involved many interacting active ingredients in mitigating disability for older adults. Future studies should specify and evaluate active ingredients within nonpharmacological interventions to optimize effects on disability in late life. This review identified several research directions to reduce disability into old age.

Supplementary Material

Supplementary data are available at *The Gerontologist* online.

Conflict of Interest

We have no conflict of interest to declare.

Author's Contributions

C. Y. W designed the study, collected and analyzed the data, and wrote the article. J. R., E. R. S., and C. Y. W. reviewed, revised, and edited the manuscript. B. F., J. K., and L. T. reviewed and edited the article. J. R., E. R. S., L. T., and C. Y. W. discussed and reviewed the data analyses. C. Y. W. is the guarantor of this work and takes responsibility for the integrity of the data, the accuracy of the data analyses, and the decision to submit and publish the article.

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