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Feasibility and Effectiveness of Intervention Programmes Integrating Functional Exercise into Daily Life of Older Adults: A Systematic Review

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Aging · Balance · Daily life · Exercise training · Lifestyle · Physical performance · Feasibility · Functional exercise · Individual activity plan · Habit formation

Abstract
Background: Traditionally, exercise programmes for improving functional performance and reducing falls are organised as structured sessions. An alternative approach of integrating functional exercises into everyday tasks has emerged in recent years. ***Objectives:*** Summarising the current evidence for the feasibility and effectiveness of interventions integrating functional exercise into daily life. ***Methods:*** A systematic literature search was conducted including articles based on the following criteria: (1) individuals ≥60 years; (2) intervention studies of randomised controlled trials (RCTs) and non-randomised studies (NRS); (3) using a lifestyle-integrated approach; (4) using functional exercises to improve strength, balance, or physical functioning; and (5) reporting outcomes on feasibility and/or effectiveness. Methodological quality of RCTs was evaluated using the PEDro scale. ***Results:*** Of 4,415 articles identified from 6 databases, 14 (6 RCTs) met the inclusion criteria. RCT quality was moderate to good. Intervention concepts included (1) the Lifestyle-integrated Functional Exercise (LiFE) programme integrating exercises into everyday activities and (2) combined programmes using integrated and structured training. Three RCTs evaluated LiFE in community dwellers and reported significantly improved balance, strength, and functional performance compared with controls receiving either no intervention, or low-intensity exercise, or structured exercise. Two of these RCTs reported a significant reduction in fall rate compared with controls receiving either no intervention or low-intensity exercise. Three RCTs compared combined programmes with usual care in institutionalised settings and reported improvements for some (balance, functional performance), but not all (strength, falls) outcomes. NRS showed behavioural change related to LiFE and feasibility in more impaired populations. One NRS comparing a combined home-based programme to a gym-based programme reported greater sustainability of effects in the combined programme. ***Conclusions:*** This review provides evidence for the effectiveness of integrated training for improving motor performances in older adults. Single studies suggest advantages of integrated compared with structured training. Combined programmes are positively evaluated in institutionalised settings, while little evidence exists in other populations. In summary, the approach of integrating functional exercise into daily life represents a promising alterna-

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tive or complement to structured exercise programmes. However, more RCTs are needed to evaluate this concept in different target populations and the potential for inducing behavioural change.

Introduction

Exercise programmes specifically developed for improving functional performance play an important role in maintaining functional independence and reducing falls in older adults [1–3]. Several programmes have been positively evaluated in different target populations [4–6]. While the exercise content differs among these programmes, all of them are delivered in a structured format either in groups [7–10] or individually at home [4, 11–13]. Common characteristics are standardised repetitive exercises, performed several times a week. While structured programmes are an essential element of intervention strategies [14], authors have repeatedly discussed the lack of long-term adherence to them [15, 16]. Survey data suggest that the proportion of persons aged 65 years or older participating in specific strength and balance training programmes is less than 13% [17].

For many older adults, engagement in structured exercise or sport is not appealing [18, 19]. This is often related to a lack of transportation, limited access to facilities [20], time commitments [21–23], unwillingness to join a group [22], or aversion to exercise, as some do not regard themselves as "sporty" [18]. Recent studies highlight older adults' preference for lifestyle activities, such as cleaning or gardening, rather than performing specific exercises [24]. Structured programmes typically do not include a behavioural change concept for fostering long-term adherence and habitualisation of exercise. The development of alternative approaches for those who are not interested in structured exercise and which implement behavioural change concepts has been repeatedly requested [7, 21, 25].

Integrating exercises into daily life has been discussed as one promising alternative to structured programmes [25, 26]. Integrated programmes aim to turn daily routines into opportunities for exercising rather than performing separate exercises. Some studies have focused solely on increasing daily walking time, for instance by walking to the store rather than taking the bus [27, 28]. This approach has been expanded to integrate various functional exercises designed for improving balance and strength [29]. Functional exercises are performed with the purpose of enhancing basic everyday motor performances, e.g. stair climbing, obstacle crossing, or rising from a chair, and are based on the principle of specificity of training [29]. Studies suggest that functional exercise training is effective because the training content is linked to the specific outcome (i.e., being closely aligned with daily tasks) [29, 30]. Examples of integrated training tasks are squatting when reaching to a low shelf or drawer, or intentionally stepping over objects in the daily environment for practising a specific motor skill, which is relevant for safe ambulation.

One advantage of integrated training is that it can be performed without reserving extra time for training. It has been proposed that integrated training may become habitual after a period of regular practice [25, 26, 31].

Integrated training seems to be a promising concept. The aim of this systematic review is to summarise the available evidence for the feasibility and effectiveness of lifestyle-integrated functional exercise training in older adults.

Methods

A systematic literature search was performed in May 2016 according to the PRISMA statement [32]. Searches were conducted in PubMed, Web of Science, Cochrane Library, PsycInfo, CINAHL, and GeroLit without any language or publication date restrictions. Initial search terms were compiled and iteratively refined by content experts in the fields of geriatrics, gerontology, exercise, and library science. The PubMed search strategy (online suppl. Table S1; for all online suppl. material, see www.karger.com/doi/10.1159/479965) was modified for the other databases.

Inclusion criteria were: (1) individuals aged ≥60 years; (2) intervention studies including randomised controlled trials (RCTs) and non-randomised studies (NRS) (e.g., controlled before-after studies); (3) use of a lifestyle-integrated approach; (4) use of functional exercises focusing on strength, balance, or physical functioning; and (5) reporting outcomes about feasibility and/or effectiveness (i.e., balance, strength, physical functioning, mobility, falls, and psychosocial aspects). Reference lists of relevant articles were subsequently hand-searched to identify additional appropriate articles.

Study selection was performed by 2 independent reviewers (M.W., T.G.). In case of disagreements, the articles were discussed with the other authors. Titles and abstracts of retrieved references were screened for inclusion, and full texts of potential articles were analysed further to determine inclusion. Data extraction included information about study design and aims, setting, sample characteristics, outcome parameters, adherence, adverse events, and results. Authors were contacted for additional information that was not available from the articles. We aimed to include all intervention studies that evaluated aspects of feasibility and/or effectiveness of integrated training, regardless of study design. We report study results separately for RCTs and NRS. Methodological qual-

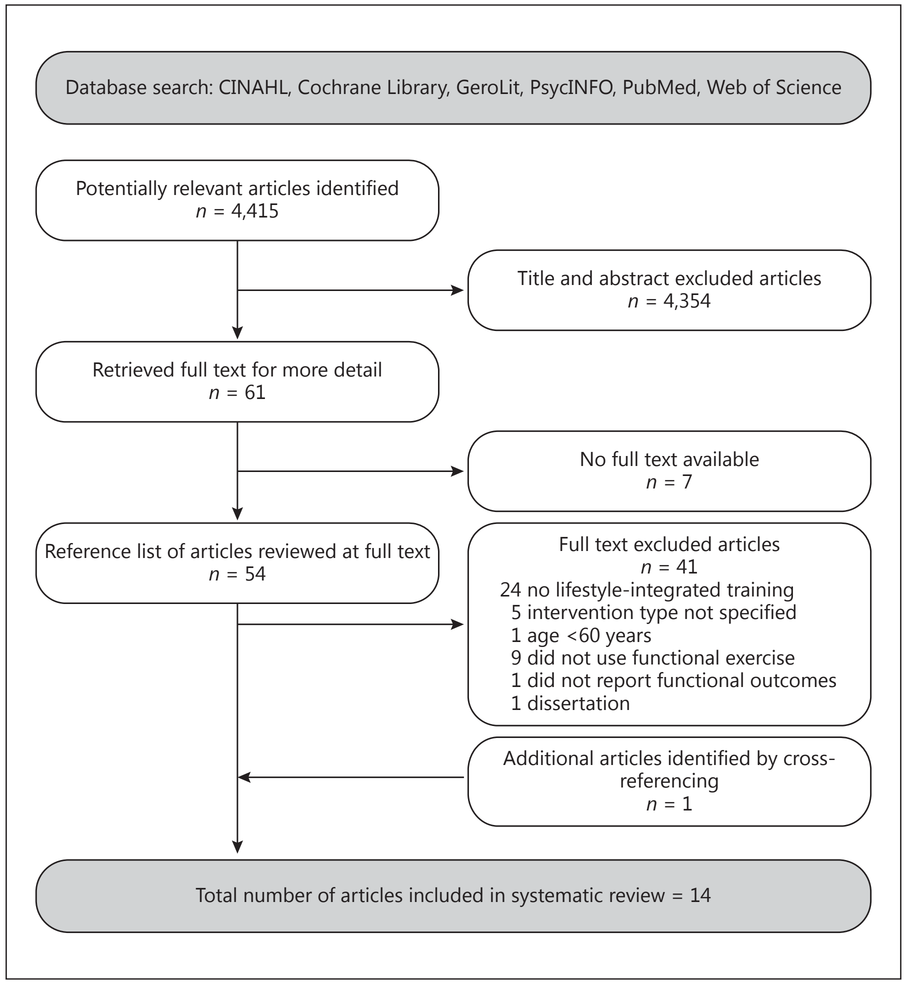

Fig. 1. Flowchart showing the literature search and the extraction of studies meeting the inclusion criteria.

ity of RCTs was rated using the PEDro scale ranging from 0 to 11 points [33]. Risk of bias was assessed using the Cochrane Collaboration's Risk of Bias Tool [34].

Results

Study Selection

Out of 4,415 articles screened, 14 met the inclusion criteria (Fig. 1). Among these, 7 [25, 26, 35–39] reported RCTs. One RCT was published in 2 articles on short- [35] and long-term effects [36]. In total, 6 RCTs were included. Seven articles [40–46] reported NRS. Among these, 3 articles [40–42] reported before-after studies focusing on feasibility [40–42], acceptance [41, 42], motor performances [40–42], and behavioural change [41]. Four articles [43–46] reported 1 controlled trial including effects on fitness and cardiorespiratory risk factors [46], and short- [43] and long-term effects on physical activity (PA) [44, 45].

Methodological Quality

Quality rating of RCTs is shown in Table 1. The average PEDro Score was 7.8 points (range 7–9). Methodological weaknesses were lack of concealed allocation [37–39], lack of participant blinding (all RCTs), and dropout rates >15% [26, 37, 38].

Risk of bias rating was performed for all articles included (online suppl. Table S2). No article had risk of bias related to incomplete outcomes and selective reporting, 6 NRS articles had risk of selection bias [40–46], and 5 articles (2 RCTs [37, 39], 3 NRS [40–42]) had a risk of performance bias.

Studies Using an RCT Design

An overview of RCTs is provided in Table 2. In summary, RCTs compared the interventions with passive controls [25], controls receiving ordinary care [37–39], or structured exercise [26, 35, 36]. Included were community dwellers with a history of falls [25, 26] or receiving

Table 1. Results of quality scoring of RCTs using the PEDro Scale

	Burton et al. [35, 36]	Clemson et al. [25]	Clemson et al. [26]	Grönstedt et al. [37]	Kerse et al. [38]	Peri et al. [39]
Eligibility criteria specified	×	×	×	×	×	×
Random allocation	×	×	×	×	×	×
Concealed allocation	×	×	×	–	–	–
Groups similar at baseline	×	×	×	×	×	×
Participant blinding	–	–	–	–	–	–
Therapist blinding	–	–	–	–	–	–
Assessor blinding	–	×	×	×	×	×
<15% dropouts	×	×	–	–	–	×
Intention-to-treat analysis	×	×	×	×	×	×
Between-group statistical comparison	×	×	×	×	×	×
Point measures and variability data	×	×	×	×	×	×
Sum score	8	9	8	7	7	8

PEDro, Physiotherapy Evidence Database, studies are classified as excellent (9–11 points), good (6–8 points), fair (4–5), and poor (<4); ×, criterion is evidenced in the article; –: criterion is not evidenced, not applicable, not coded, or could not be determined in the article.

restorative home care [35, 36], and institutionalised older adults [37–39]. Sample sizes ranged from 34 to 473 participants, mean age from 80.2 to 85.0 years, and percentage of women from 50 to 85%.

Interventions

The intervention period ranged from 8 weeks [35, 36, 40] to 12 months [38]. The programmes were delivered by physio- and occupational therapists [25, 26, 35, 36], home-help service staff [37], or usual caregivers [38, 39]. All RCTs consistently recommended that integrated exercises should be performed daily, as often as possible throughout the day.

The most frequently evaluated intervention was the Lifestyle-integrated Functional Exercise (LiFE) programme [25, 26, 35, 36]. LiFE focuses on embedding functional exercises into daily life, thereby enhancing the overall level of PA. The programme is taught by professional trainers during 5–7 home visits and 2 follow-up phone calls over a 6-month period [47].

A participants' manual illustrates the LiFE "principles" for improving balance, lower-limb strength, and increasing PA [48]. Balance principles include postures and walking with gradual reduction in the base of support (e.g., upgrading tandem stand to one-leg stand over time), and dynamic movements that perturb the centre of gravity (e.g., leaning in different directions, stepping over obstacles) [26]. Strength principles include functional activities focusing on improving lower extremity muscles around the hip and knee (e.g., squatting, chair rise, sideward walking) and ankle (e.g., toe stand, toe and heel walking) with gradual increase of intensity through performing more challenging activities [26]. Important elements of LiFE are strategies for behavioural change, based on habit re-framing theory [49]. LiFE activities are linked to daily tasks by using situational and environmental cues (e.g., tooth brushing) as prompts to action. The idea of LiFE is to perform the activities intentionally and consciously until they become a habit.

Two RCTs evaluated the LiFE programme in older fallers [25, 26]. One of these RCTs [25] used a control group not receiving any intervention. The other [26] compared LiFE with a structured exercise programme which included balance and strength exercises (with ankle cuff weights) performed 3 times a week at home. As with LiFE, the structured training was taught by professional trainers during 5–7 sessions and 2 follow-up phone calls over a 6-month period [47]. Participants in a third group (controls) performed low intensity and flexibility exercises taught during 2 sessions, 1 booster session, and 6 follow-up phone calls.

One RCT [35, 36] evaluated a modified version of LiFE in a restorative home care setting. The teaching period was shorter (8 weeks). Care managers (health professionals, nurses) taught the programme during regular visits every 10–14 days (3 times on average). LiFE was compared with structured training including balance and

Table 2. Description of the 10 trials with regard to study purpose, subjects, settings, and interventions

First author [Ref.]	Study design	Study purpose	Subjects and setting	Intervention	Behaviour change approach	T, F, D	Delivery of the intervention	Follow-up	Adherence
Randomised controlled trials									
Burton [35, 36]	Pragmatic RCT	Compare the effectiveness of LiFE vs. structured exercise on greater functional gains	n = 80 Mean age: IG: 80.2 years, CG: 79.6 years Female: IG: 75%, CG: 90% Dropout: IG: 2.5%, CG: 7.5%	IG: LiFE CG: structured balance and strength exercises	Habit formation framework aiming to make LiFE activities habitual	IG: T: individualized F: daily D: 8 weeks CG: T: 15–20 min F: 3× weekly D: 8 weeks	IG: PTs, OTs, nurses, 5 home visits CG: restorative home care team	8 weeks and 6 months	IG: 4.05 times/week (4.91 times/week during the 8 weeks, 3.62 times/week at follow-up) CG: 3.66 times/week (4.42 times/week during the 8 weeks, 3.28 times/week at follow-up)
Clemson [25]	Pilot RCT	Determine the adherence and effectiveness of LiFE on fall prevention	n = 34 Mean age: IG: 81.0 years, CG: 82.0 years Female: IG: 50%, CG: 44%, Dropout: 11.1%	IG: LiFE CG: none	Habit formation framework aiming to make LiFE activities habitual	T: individualized F: daily D: 3 months	PTs, OTs, 5 home visits, 2 booster phone calls, 2 follow-up phone calls	3 months and 6 months	N/A
Clemson [26]	Randomized parallel trial	Determine the effectiveness of LiFE on fall prevention	n = 317 Mean age: 83.4 years Female: 54.9% Dropout: IG: 26.2%, IG: 7.5%, IG2: 8.6%, CG: 13.3%	IG1: LiFE IG2: structured balance and strength exercises CG: gentle and flexibility exercises	Habit formation framework aiming to make LiFE activities habitual	IG1: T: individualized F: daily D: 6 months IG2: T: N/A F: II: 3× weekly D: II: 6 months CG: T: N/A F: N/A D: 6 months	IG1 and IG2: PTs, OTs, 5 home visits, 2 booster phone calls, 2 follow-up phone calls CG: PTs, OTs, 2 home visits, 2 booster phone calls, 6 follow-up phone calls	6 months and 12 months	IG1: 33% (over 6 months), poor adherence (<25%): 7% IG2: 29% (over 6 months), poor adherence (<25%): 19% CG: 34% (over 6 months), poor adherence (<25%): 11%
Grönstedt [37]	Randomized clinical trial	Determine the effectiveness of an individually tailored intervention program on function	n = 332 Mean age: 85.0 years Female: 73.5% Dropout: IG: 15.9%, CG: 17.8%	IG: individually tailored physical and daily activities in different combination CG: ordinary care and treatment	Individual goal setting strategies related to physical and daily activities	T: individualized F: daily D: 3 months	OTs, PTs, staff members at the unit, daily visits	3 months	N/A
Kerse [38]	Cluster RCT	Determine the effectiveness of an individualized functional activity program on quality of life	n = 473 Mean age: 84.3 years Dropout: IG: 32%, CG: 29%	IG: individualized program of physical activities based on repetitions of activities of daily living CG: usual care	Behavioural strategies focusing on goal setting for improving physical function	T: individualized F: daily D: 12 months	Healthcare assistants, number of visits depend on resident's needs	3 months, 6 months and 12 months	N/A
Peri [39]	Cluster RCT	Determine the effectiveness of an individualized functional activity programme on function, mobility and quality of life	n = 149 Mean age: 84.7 years Female: IG: 85%, CG: 83% Dropout: IG: 13.7%, CG: 19.7%	IG: individualized program of physical activities based on repetitions of activities of daily living CG: usual care	Behavioural strategies, focusing on goal setting for improving physical function	T: individualized F: daily D: 6 months	Healthcare assistants, number of visits depend on resident's needs	3 months and 6 months	N/A

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Table 2 (continued)

First author [Ref.]	Study design	Study purpose	Subjects and setting	Intervention	Behaviour change approach	T, F, D	Delivery of the intervention	Follow-up	Adherence
Non-randomised studies									
Opdenacker [43–45] Van Roie [46]	Controlled trial	Determine the effectiveness of a lifestyle intervention vs. structured exercise on physical activity and on self-esteem	*n* = 186 Mean age: IG1: 63.3 years, IG2: 67.0 years, CG: 67.9 years Female: IG1 and IG2: 50%, CG: 54.5% Dropout: IG1: 23.3%, IG2: 18.3%, CG: 30.3%	IG1: Home-based lifestyle intervention, including endurance, strength, flexibility and balance IG2: structured exercise program, including endurance, strength, flexibility and balance CG: assessments	Behavioural strategies, derived from self-determination theory, transtheoretical model and social-cognitive theory, targeting self-supportive behaviour (enhancing autonomy, reducing support)	IG: T: individualized F: daily D: 11 months IG2: T: 60–90 min F: 3× weekly D: 11 months	IG1: exercise psychologist, 1 home visit, 5 monthly collective sessions, 16 booster phone calls IG2: instructors at a fitness centre	6 months, 11 months and 23 months	IG1: 85.5% (11 post-test), 87.0% (follow-up) IG2: 82.8% (post-test), 83.7% (23 follow-up) C: N/A
Burton [40]	Before-after study	Test the feasibility of LiFE in terms of suitability in restorative home care	*n* = 9 Mean age: 80.8 years Female: 75% Dropout: 11.1%	IG: LiFE, including 7 balance and 6 strength principles CG: none	Habit formation framework aiming to make LiFE activities habitual	T: individualized F: daily D: 8 weeks	PTs, OTs, nurses, 5 home visits	8 weeks	N/A
Fleig [41]	Before-after study	Test the feasibility of a group-based EASY-LiFE intervention in terms of habit formation	*n* = 13 Mean age: 66.2 years Female: 100% Dropout: 23.1%	IG: group-based LiFE CG: none	Phase-specified behavioural change techniques making everyday actions habitual	T: individualized F: daily D: 4 months	Exercise physiologists, personal trainer, health psychologists, 7 group sessions	6 months	N/A
Keay [42]	Before-after study	Determine the feasibility of LiFE in older adults with visual impairment	*n* = 16 Mean age: 70.0 years Female: 92.9% Dropout: 6.2%	IG: LiFE CG: none	Habit formation framework aiming to make LiFE activities habitual	T: individualized F: daily D: 3 months	Trained orientation and mobility instructors, 7 home visits	5 months	N/A

RCT, randomized controlled trial; LiFE, lifestyle-integrated functional exercise; LAT, LiFE assessment tool; PT, physiotherapists; OT, occupational therapists; PA, physical activity; SB, sedentary behaviour; N/A, not available; IG, intervention group; CG, control group; T, time bout; F, frequency; D, duration.

strength exercises performed 3 times a day. The structured training was also taught by care managers with similar frequency and duration.

Three RCTs evaluated combined programmes including structured training and lifestyle-integrated basic functional exercises [37–39]. One of these RCTs [37] aimed at preventing functional decline in nursing home residents. Structured training including practise of transfers, walking, functional balance, and strength exercises, was taught by physio- and occupational therapists within individual supervised sessions (frequency and duration were not specified). Additionally, residents were taught on self-administered training and incorporating the functional exercises into daily routines. Exercises were selected based on individual treatment goals and taught by physio- and occupational therapists (frequency and duration not specified).The intervention was compared with usual care within a 3-month trial.

The 2 other RCTs on combined training [38, 39] aimed at improving mobility and quality of life of older adults living in long-term residential care using the Promoting Independence in Residential Care (PIRC) training. PIRC focuses on basic functional exercise training (e.g., chair rising and walking during daily routines). Exercises are designed to increase strength, balance, and endurance. They are performed either fully integrated into daily routines or supervised at least twice a day. Exercise intensity depends on participant's capabilities and is upgraded during the course of the intervention (e.g., increasing repetitions). In the 2 RCTs [38, 39], exercise frequency and duration were not specified. Gerontology nurses and healthcare assistants implemented PIRC based on individuals' treatment goals and functional performance level. An activity programme displayed in the participant's room was used to encourage residents' engagement. Both RCTs compared PIRC to controls receiving usual care over a period of 6 [39] and 12 months [38].

Dropouts from Study

For LiFE, the number of dropouts was lower (5 [35, 36] to 18% [26]) compared with structured training (7.5 [35] to 21% [26]) and passive controls (25%) [25], and identical to an active control group (18% [26]) (Table 2).

For combined programmes, 1 RCT reported higher dropouts in the intervention (32%) compared with controls (29%) [38], while 2 reported lower dropouts for the intervention (13.7% [39], 15.9% [37]) compared with controls (19.1% [37], 19.7% [39]). Main factors for dropouts were unrelated to the programme, including death

[37–39], illness [25, 26], health problems [25, 26], or moving [25, 26, 37], while some were related to the intervention, such as pain or lack of training partners [26].

Adherence

For LiFE, adherence was measured through an activity planner, in which participants documented their daily LiFE activities. One study compared adherence in LiFE with adherence in structured training. Completing predefined LiFE activities for ≥3 days/week or structured home exercises 3 times a week was rated as 100% adherence [50]. Results showed significantly higher adherence to LiFE (64% of participants) compared with structured training (53%) [26]. Poor adherence (<25%) was apparent in 7% of LiFE and 19% of structured training participants [26]. In 2 other RCTs, adherence was reported as the number of days of LiFE practice or structured training per week, respectively [35, 36]. During the intervention period, adherence for LiFE was higher (4.91 days/week) compared to structured training (4.42) [35, 36]. Four months after the intervention, adherence to both programmes was similar (3.62 vs. 3.66) [36]. During follow-up, 1 study reported significantly higher adherence to the LiFE programme (64% of participants), in comparison with structured exercising (53%). Three studies did not report adherence [25]. For combined programmes, adherence was not reported [37–39].

Adverse Events

In an RCT with 317 participants, 1 participant in the LiFE group was diagnosed with a pelvic stress fracture and attributed this to increased walking and stair climbing, but continued with the programme [26]. In the structured comparison group, 1 participant had a surgery for an inguinal hernia and withdrew from the programme, but it was unclear whether this was related to the intervention.

An RCT on PIRC reported fatigue in 31% of the intervention group and 43% of controls [39]. No adverse events were reported in other RCTs [25, 35–38].

Effectiveness on Motor Performances

Table 3 summarises the effects on outcome measures.

Balance. LiFE was more effective for improving some, but not all, balance outcomes during short-term (8 weeks) and long-term assessments (6 and 12 months) compared with structured training [26, 35, 36], passive controls [25]), or control exercise [26]. Inconsistent results were found for combined programmes, with 1 study reporting significant improvement in the intervention group compared with usual care [37], while others did not [38, 39].

Lower-Limb Strength. Effects for lower-limb strength varied. One RCT reported greater improvements for some (i.e., ankle), but not all (i.e., knee and hip) strength measures for LiFE compared with structured training during short- and long-term assessment [26]. No additional effects for LiFE, compared with structured training, were found in 2 studies [35, 36]. Compared with inactive controls, LiFE significantly increased knee [25], but not hip strength. For combined programmes, effects were either insignificant [38, 39] or not measured [37].

Functional Performance. LiFE was more effective for improving functional performance, measured by performance-based tests or self-report measures shown in Table 3, compared with structured training. For combined programmes, 1 RCT reported significantly improved functional leg muscle strength, measured by timed chair rises, in the intervention while controls deteriorated [37]. Within PIRC, effects on self-reported function were only present in the subsample of cognitively intact participants [38, 39].

Effectiveness for Increasing PA

One RCT showed greater effects of LiFE on PA and energy expenditure compared with structured training [26]. Another RCT did not report increased PA after LiFE compared to passive controls [25].

An RCT evaluating a combined programme reported significant improvements in PA, energy expenditure, and life space (i.e., distance travelled between and within home) in the intervention compared with usual care [37].

Effectiveness for Reducing Falls

For LiFE, a significant reduction in fall rate (31%) in comparison with controls (gentle and flexibility exercises) was reported [26]. Descriptive data showed a non-significant lower rate of falls in LiFE (172 falls) as compared with structured exercise (193) at 12-month follow-up [26]. Another RCT showed a significantly reduced relative risk for falls in LiFE (RR = 0.21) in comparison with controls [25]. For combined programmes, effects were either insignificant [38, 39] or not measured [37].

Studies Using an NRS Design

NRS studies are shown in Table 2. Three before-after studies evaluated the feasibility of LiFE in different settings (i.e., restorative home care [40]), different target populations (i.e., visually impaired [42]), or different administration mode (i.e., group-based [41]). One of them

Table 3. A summary of results reported in the 10 trials with regard to main physical outcome dimensions and measurements

First author [Ref.]	Outcome dimension	Outcome measurements	Outcomes: post-intervention	Outcomes: long-term follow-up		
Randomised controlled trials						
Burton [35, 36]			IG vs. CG:	IG vs. CG:		
	Balance	Functional reach Tandem walk Tandem walk errors	Functional reach: ns Tandem walk: IG↑ Tandem walk errors: IG↑	Functional reach: ns Tandem walk: IG↑ Tandem walk errors: IG↑		
	Muscle strength	Chair rise	Chair rise: ns	Chair rise: ns		
	Functional mobility	TUG	TUG: ns	TUG: ns		
	Self-efficacy	FES ABC Scale	FES: ns ABC Scale: IG↑	FES: ns ABC Scale: IG↑		
	Health-related outcomes	Vitality Plus Scale	Vitality Plus Scale: IG↑	Vitality Plus Scale: IG↑		
	Function	LLFDI	LLFDI: IG↑ for limitation, function total, basic and advanced lower extremity	LLFDI: IG↑ for basic and advanced lower extremity		
Clemson [25]			IG vs. CG:	IG vs. CG:		
	Balance	Static balance (tandem stand, one-leg stand) Dynamic balance (tandem walk)	Static balance: ns Dynamic balance: IG↑	Static balance: ns Dynamic balance: ns		
	Strength	Static hip strength Static knee strength Static ankle strength	Static hip strength: ns Static knee strength: IG↑ for left knee Static ankle strength: ns	Static hip strength: ns Static knee strength: ns Static ankle strength: ns		
	Falls	Number of falls	Number of falls: IG↑	Number of falls: IG↑		
	Self-efficacy	FES (modified) ABC Scale	MFES: IG↑ ABC Scale: ns	MFES: ns ABC Scale: IG↑		
	Health-related outcomes	Markus Exercise Self-Efficacy Scale SF-36	Markus Exercise Self-Efficacy Scale: ns SF-36: ns	Markus Exercise Self-Efficacy Scale: ns SF-36: ns		
	Physical activity	Life Space Index	Life Space Index: ns	Life Space Index: ns		
Clemson [26]					IG1 vs. CG	IG2 vs. CG
	Balance	Five level balance scale (SPPB) Eight level balance scale Tandem walk	–/–	5-level balance scale: *d*, sig 8-level balance scale: *d*, sig Tandem walk: *d*, sig	0.55↑ 0.63↑ 0.42↑	0.33 ns 0.29 ns 0.49↑
	Strength	Maximal isometric lower hip strength Maximal isometric knee strength Maximal isometric ankle strength		Static hip strength: *d*, sig Static knee strength: *d*, sig Static ankle strength: *d*, sig	N/A, ns N/A, ns 0.40↑	N/A, ns N/A, ns 0.17 ns
	Falls	Number of falls		Number of falls: IRR, sig	0.69↑	0.81 ns
	Self-efficacy	ABC scale		ABC Scale: *d*	0.38↑	0.37↑
	Function	Late Life Disability Index (LLDI) Late Life Function Index (LLFI) NHANES independence measure for ADL		LLDI: *d*, sig LLFI: *d*, sig NHANES: *d*, sig	0.73↑ 0.49↑ 0.54↑	0.41 ns 0.17↑ 0.26 ns
	Health-related outcomes	EQ-VAS EQ-5D PASE		EQ-VAS: *d*, sig EQ-5D; *d*, sig PASE: *d*, sig	0.34↑ N/A, ns 0.25↑	0.06 ns N/A, ns 0.05 ns
	Physical activity	Paffenberger physical activity index Life Space Index		Paffenberger index: *d*, sig Life Space Index: *d*, sig	0.62↑ N/A, ns	0.36↑ N/A, ns
Grönstedt [37]			IG vs. CG			
	Activities of daily living	Functional Independence measure (FIM) BBS	FIM: ns BBS: IG↑			
	Balance	Nursing Home Life Space Diameter (NHLSD)	NHLSD: IG↑			

Table 3 (continued)

First author [Ref.]	Outcome dimension	Outcome measurements	Outcomes: post-intervention	Outcomes: long-term follow-up		
	Physical activity	10 m indoors walking or wheelchair propulsion	Walking or wheelchair propulsion: ns			
	Mobility	Physiotherapy Clinical Outcome Variables (COVS)	COVS: IG↑			
	Strength	Dynamometer Chair rise	Dynamometer: ns Chair rise: ns			
	Falls Self-Efficacy	FES, Swedish version	FES-S: ns			
Kerse [38]			IG vs. CG:	IG vs. CG:		
	Function	LLFDI TUG EMS FICSIT-4-balance test	LLFDI: IG↑ (cognitively normal group) TUG: ns EMS: ns FICSIT-4-balance test: ns	LLFDI: ns TUG: ns EMS: FICSIT-4-balance test: ns		
	Quality of life	EuroQol instrument Life Satisfaction Index (LSI)	EuroQol instrument: ns LSI: ns	EuroQol instrument: ns LSI: ns		
	Fall-related outcomes	Number of falls Modified fear of falling scale	Number of falls: ns Modified fear of falling scale: #	Number of falls: ns Modified fear of falling scale: #		
	Psychological outcomes	Geriatric depression scale	Geriatric depression scale: IG↓ (cognitively impaired group)	Geriatric depression scale: IG↓ (cognitively impaired group)		
Peri [39]			IG vs. CG:	IG vs. CG:		
	Mobility	EMS TUG	EMS: ns TUG: ns	EMS: ns TUG: ns		
	Health-related outcomes	SF-36	SF-36: IG↑ for physical component	SF-36: ns		
	Psychological outcomes	LSI	LSI: ns	LSI: ns		
	Falls	Number of falls	Number of falls: ns	Number of falls: ns		
Non-randomised studies						
Opdenacker [43–45] Van Roie[a] [46]			IG1 vs. IG2:	IG1 vs. IG2:		
	Physical activity	Accelerometer Daily steps Flemish Physical Activity Computerized Questionnaire (FPACQ)	Accelerometer: ns Daily steps: IG1↑ FPACQ: IG1↑ for active transportation	Accelerometer: ns Daily steps: IG1↑ FPACQ: ns		
	Psychological measures	Rosenberg Self-Esteem Scale Physical Self-Perception Profile (PSPP) Self-Efficacy questionnaire	Rosenberg Self-Esteem: ns PSPP: ns Self-efficacy: ns	Rosenberg Self-Esteem: ns PSPP: ns Self-efficacy: ns		
					Pretest	Posttest
	Cardiorespiratory fitness	Maximal exercise test	Maximal exercise test: IG2↑	Maximal exercise test:	ns	IG2↓
	Muscular fitness	Static knee strength Dynamic knee strength Total work (strength endurance test)	Static strength: IG2↑ Dynamic strength: IG2↑ Total work: IG2↑	Static strength: Dynamic strength: Total work:	IG2↑ ns ns	IG2↓ IG2↓ IG2↓
	Functional performance	Arm curl test Chair rise Vertical jump	Arm curl test: ns Chair stand test: ns Vertical jump: ns	Arm curl test: Chair rise: Vertical jump:	IG1↑ IG1↑ ns	IG2↓ IG2↓ IG2↓
Burton [40]	Balance	Functional reach Tandem walk Tandem walk errors	Functional reach: ns Tandem walk: ↑ Tandem walk errors: ns	–/–		
	Muscle strength	Chair rise	Chair rise: ns			
	Functional mobility	TUG	TUG: ns			
	Falls	Number of falls	Number of falls: ↑			
	Self-efficacy	FES ABC Scale	FES: ↑ ABC Scale: ns			

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Table 3 (continued)

First author [Ref.]	Outcome dimension	Outcome measurements	Outcomes: post-intervention	Outcomes: long-term follow-up
	Health-related outcomes	Vitality Plus Scale LLFDI	Vitality Plus Scale: ns LLFDI: ↑ for function total	
	Function	PASE	PASE: ↑	
	Physical activity	Actical accelerometer	Actical accelerometer: ns	
Fleig [41]	Mobility	SPPB	SPPB: ns	–/–
	Psychological outcomes	Intention to engage in balance and strength Self-efficacy Action planning Action control Coping planning Automaticity Habit strength Self-identity	Intention: ns Self-efficacy: ns Action planning: PE # Action control: PE # Coping planning: ns Automaticity: PE# Habit strength: PE# Self-identity: PE#	
	Subjective health	EQ5D-5L	EQ5D-5L: ns	
Keay [42]	Mobility Function Falls Self-Efficacy	SPPB LLFDI Short FES-I	SPPB: ns LLFDI: ↑ for function Short FES-I: ↑	–/–

d, effect size (Cohen's *d*) for discriminating between different intervention groups; IRR, incidence rate ratio; PE, positive effect; NE, negative effect; #, insufficient or contradictory data and/or analyses; ↑, significant improvement; ↓, significant deterioration; ns, not significant; N/A, not available; TUG, Timed Up and Go test; FES, Falls Efficacy Scale; ABC, Activities specific Balance Confidence; LLFDI, Late Life Function and Disability Index; PASE, Physical Activity Scale for the Elderly; SPPB, Short Physical Performance Battery; EQ5D/EQ-VAS, health-related quality of life; SF-36, Short-form health survey; BBS, Berg Balance Scale; ADL, activities of daily living; EMS, Elderly Mobility Scale. [a] Results of the study were reported in 4 articles focusing on different outcome dimensions.

additionally evaluated effects on behaviour change [41]. One controlled trial compared a combined "Home-Based Lifestyle" (HBL) intervention and a gym-based structured exercise programme [43–46].

Sample sizes ranged from 8 [40] to 86 participants [43–46], mean age from 63.3 [43–46] to 80.8 years [40], and percentage of women from 50 [43–46] to 100% [41].

Interventions

Two feasibility studies [40, 42] adapted LiFE to different settings and target populations. One implemented LiFE in a restorative home care service. Allied healthcare managers (health professionals and nurses) delivered the programme over a short intervention period of 8 weeks (instead of 6 months) [40]. The other adapted LiFE for visually impaired fallers by providing the written manual and/or an additional audio version. LiFE was taught by orientation and mobility staff during 7 home visits over a 3-month period, with 1 follow-up phone call after 5 months.

A third study tested the feasibility of group-based LiFE [41]. Instead of individual teaching, a team (exercise physiologist, health psychologist, personal trainer) taught LiFE within 7 group sessions over a 4-month period. During group sessions, participants learned LiFE activities and developed an individual activity plan. Participants practised LiFE unsupervised in their everyday environment, similar to the original LiFE concept.

One controlled trial evaluated the HBL concept aimed at improving PA, cardiorespiratory and muscular fitness, and functional performance in sedentary older adults [43–46]. HBL is a combined programme including integrated functional exercise (e.g., climbing stairs, squatting while gardening), integrated PA (e.g., walking instead of taking the bus), and structured exercises focusing on balance (e.g., one-leg stand while standing behind a chair), strength (e.g., arm curls), and endurance (e.g., jogging, cycling, or hiking). Structured balance and strength exercises were performed for 8–20 repetitions 2–3 times a week, and endurance training at least 20 min, 3 times a week.

In the controlled trial, HBL was taught during an initial home visit by an exercise psychologist, 16 booster phone calls, and 5 monthly collective group sessions over a period 11 months [43–46]. Information on exercise content and behaviour change were provided by the trainer, a brochure, and a participants' manual. HBL was compared to a group-based structured, supervised programme including balance, strength, flexibility, and endurance exercises performed 3 times a week for 60–90 min in a gym. The control group, recruited separately (not randomised), did not receive any intervention [43–46].

Dropouts from Study

For LiFE, the percentage of dropouts ranged between 6.3% [42] and 23.1% [41] and was related to health problems [40, 41] and family emergencies [41], both unrelated to the programme. Dropout rates were similar for the HBL group (23%) compared with the gym-based exercise (18%) [43–46] and were related to health problems unrelated to the programme or a lack of motivation [43–46] (Table 2).

Adherence

No LiFE studies reported on adherence. For HBL, adherers were defined as those having completed 80% of their programme (not further specified), whereas participants in the gym-based group had to complete 5 out of 6 training sessions in 2 consecutive weeks [43–46]. Adherence was similar for HBL (78%) and gym-based exercise (80%) [43–45].

Adverse events

No study reported on adverse events.

Feasibility of the Intervention

LiFE was feasible in different settings and target populations given that adjustments to particular activities were made [40–46]. Care managers and clients found the LiFE manual clear and easy to understand, but tools for tailoring and monitoring the intervention were perceived as too time-consuming and were replaced by a routine functional assessment performed during home care visits in a subsequent RCT [35, 36].

For visually impaired, LiFE was generally suitable and easy to undertake [42]. Most of participants valued the improvements in balance, strength and overall performance in daily tasks. The delivery through their orientation and mobility instructors and the programme's focus on physical technique were especially emphasised. They appreciated being able to make their own decisions regarding appropriate, but also challenging, exercises and the integration into daily life, increasing the sustainability after completing the programme. However, participants commented on the excessive paper work and some found the manual too long. Both instructors and participants reported difficulties related to reduced vision which prevented participation in specific LiFE activities, including "stepping in different directions," "leaning side to side," and "leaning forwards and backwards." These activities were either too difficult to teach, or participants were unable to perform them, or they were perceived as uncomfortable due to a greater sensation of falling and sense of vulnerability related to their vision impairment. Instructors recommended increasing the number of sessions and enlarge the recording sheets in this specific target population.

For group-based LiFE, most participants valued the group format, appreciating the opportunity of social interaction and exchanging ideas about LiFE activities [41]. Some participants criticised the group setting as they experienced a slowdown in individual progress. Some requested individual face-to-face sessions. Among the different LiFE components (functional assessment, exercise demonstration, behavioural change, documentation), exercise demonstrations were rated as the most important aspects, emphasising the importance of an exercise physiologist in the team. While most participants valued action planning, using LiFE activity sheets, some criticised the administrative effort, as reported in other studies [40]. Most participants valued the behavioural change approach, particularly the contextual cues to overcome problems with remembering exercising during the day. In the controlled trial, feasibility of the intervention was not analysed.

Effects on Motor Performances

Feasibility studies on LiFE [40–42] reported exercise effects, although they were not specifically designed for measuring the effectiveness of the programme.

Balance. One LiFE study reported significant improvements in dynamic balance [40], whereas the others did not [41, 42]. The HBL study did not measure balance [43–46].

Lower-Limb Strength. One LiFE study measured lower-limb strength, but did not obtain effects [40]. For HBL, the gym-based exercise group showed significantly greater improvements in knee strength during short- [46] and long-term assessment [45] compared to HBL and controls.

Functional Performance. Two LiFE studies measured self-reported functional performance and reported significant improvements [40, 42]. In the HBL study, both intervention groups (HBL and gym-based) significantly improved in functional performance (chair rise, and vertical jump) compared to controls [46], but effects were sustained only in the HBL group [45].

Effects for Increasing PA

One LiFE study measured PA and reported significant improvements [40]. For HBL, both intervention groups (HBL and gym-based) significantly improved in PA compared to controls, but effects were sustained only in the HBL group [43].

Effects for Reducing Falls

One LiFE study measured fall rate, reporting a significant reduction ($t(7) = -2.65$, $p = 0.033$) [40]. The HBL study did not measure falls [43–46].

Effectiveness of the Behavioural Change Component

The group-based LiFE induced changes in habit strength and related psychosocial determinants, including automaticity of exercising, self-identity (integration of exercises into one's self-concept), action planning, action control, increase in autonomy, awareness of health-related benefits of exercising, and skills to anticipate potential barriers. No changes were found for the intention to exercise, exercise-related self-efficacy, and planning [41]. No other studies reported this outcome.

Discussion

This systematic review evaluated studies which integrated functional exercises into daily life of older adults. We found some evidence suggesting that integrated training has advantages including higher adherence and effectiveness compared with structured training in selected populations such as community-dwelling older fallers, although the number of RCTs is low. Furthermore, we found studies which combined structured exercise with integrated training, feasible and effective, particularly in impaired target populations such as nursing home residents. Both approaches increased PA level, related to the specificity of the integrated training content aiming to foster everyday activities.

RCT Designs

Long-term training is crucial to modify individuals' behaviour, promote self-efficacy, and gain full health benefits from exercise training. Long-term adherence has often been reported as challenging for structured exercise programmes [15, 16]. In this context, integrated training concepts have been specifically designed to increase adherence by embedding exercises into daily routines. Most RCTs showed that integrated training led to higher adherence rates, compared with structured training in the short [26, 35] and long term [26], while single studies reported similar adherence for both programmes in the long term [36]. One reason for the differences in long-term adherence might be the duration of the intervention (8 weeks [36] vs. 6 months [26]), being crucial for modifying individuals' behaviour (fostering behavioural change).

Importantly, there is no consensus on how adherence should be compared between integrated and structured training. The approach of Clemson et al. [26] was defining 100% adherence when LiFE was performed for ≥3 days/week, although participants were asked to practise daily to make LiFE activities habitual [25, 26]. Moreover, no information was provided about the daily frequency, duration, and intensity of LiFE training, and the exact exercise dosage remains unclear [25, 26]. While dosage can be estimated for structured training, this is difficult for integrated training as participants perform multiple short bouts of activities over the course of a day (e.g., knee bends each time when picking something up), making it hard to count the number of repetitions and estimate intensity. Theoretically, participants could try to document this information, but this would require time-consuming paperwork. Effort for documentation was often mentioned as a drawback in studies [40–42]. A potential solution for future trials might be the use of ICT technology such as smartphones or smartwatches for documenting adherence. Such an approach is currently developed within the EU project PreventIT (www.preventit.eu).

In studies comparing structured with integrated or combined training, very few adverse events were reported [26, 39]. While these results suggest that all approaches are generally safe, the number of adverse events reported in studies was too low to compare different training modes regarding safety. Furthermore, reporting of adverse events differed among studies with some using their own definitions (self-reported muscular aches and pains, fatigue, number of falls [38, 39]) and others not reporting adverse events, hampering comparability. Our findings are in line with a review showing that nearly 20% of exercise trials report no information on adverse events and 25% do not accurately define severity [51].

Structured programmes include fixed exercise sets, standardised according to type, frequency, intensity, and duration. Besides teaching participants correct exercise performance, little knowledge is needed for successful participation in these programmes. In contrast, integrated concepts require participants to understand the theoretical underpinnings, activity principles, implementation strategies, activity planning, and documentation of adherence. When compared to structured programmes, integrated concepts can be seen as more complex interventions which require self-management strategies. Despite this increased complexity, our review shows that the interventions are feasible and acceptable to older adults [25, 26, 35–39]. Current studies suggest that successful delivery of integrated training requires well-qualified therapists, skilled in both exercise delivery and behavioural change theory [41].

Effectiveness of the Interventions

Effectiveness represents a major criterion for exercise programmes and therefore stands out within evaluation criteria. For effectively improving motor performances and reducing fall risk, exercise programmes need to be adequately challenging and progress in intensity over time [52]. For structured exercise programmes, established guidelines define optimal training modalities such as number of repetitions, and frequency [49].

While integrated training included principles for exercise progression [25, 26, 35, 36, 38, 39], frequency and number of repetitions are not specifically defined. Rather, they are determined by the frequency of the daily task in which an activity is integrated. A key question is whether these single bouts of exercises spread out over the course of the day are similarly effective compared with structured training.

We found several studies showing that LiFE training is similarly effective for improving motor performance when compared with structured training [26], and superior for selected outcomes related to balance [26, 35, 40], strength (i.e., ankle [26]), functional performance [26, 35, 36], and PA [26]. Authors discussed that the added value of LiFE might be related to the increased training dosage due to daily practice, increased level of PA (e.g. stair climbing), and higher adherence during long-term training interventions [26]. The additional effect of LiFE was particularly prominent for balance, but less for strength [25, 26, 35, 36]. For strength, an added value of integrated training is less clear, which might be related to a lack of standardised set of repetitive movements, as supposed in the strength training literature [14].

In structured programmes, participants often perform rather artificial movements, such as isolated knee extensions with weights, to improve strength of a particular muscle group. By comparison, integrated activities are functional and embedded into daily tasks, focusing on improving relevant activities of daily living such as crossing an obstacle or climbing stairs. For LiFE, studies showed that integrated training is superior to structured training for improving overall function and disability in daily life tasks [26, 35, 36], which suggests that integrated training is directly transferable into older adults' daily life and fosters mobility-related independence.

One pilot RCT on LiFE showed a reduction in falls by 80% compared with inactive controls [25]. Findings should be interpreted with caution due to a small, unrepresentative sample not allowing a generalisation of effects. Nonetheless, these findings were the impetus for a second and larger RCT which showed that LiFE reduced falls by 31% compared with active controls receiving gentle and flexibility exercises. This is comparable to effects reported for structured home exercise programmes in community-dwelling older adults (21%) [53].

Results showed that combined programmes were effective for improving balance [37–39], functional performance [37–39], PA [37], but neither strength [38, 39] nor fall-related outcomes [37–39]. While positive results on functional performances are comparable to other RCTs on integrated training in community dwellers, limited effects on strength [38, 39] and falls [38, 39] may suggest that it is more challenging to effectively implement these programmes in institutionalised older adults. Several participants complained about fatigue, which might be a potential barrier to adopting integrated exercises into everyday activities. Also, contamination effects related to the location of the RCT (nursing home) might have biased the results. The intervention and control groups were located in the same nursing home. It was not possible to prevent control participants from participating in the intervention group activities [39]. An advantage of combined programmes was the social interaction during sessions [41]. In contrast, lack of training partner was mentioned as a drawback of the LiFE programme [26]. In combined programmes, participants could share their experiences about integrated training and practise together during group sessions. On the same note, none of the combined exercise RCTs analysed whether the integrated component provided an added value compared with practising in a structured-only format. This could be evaluated in future trials.

NRS Designs

Integrated training is a rather novel concept and the number of RCTs is low. We therefore included NRS to provide additional information about feasibility and effectiveness, although they have lower evidence levels compared with RCTs.

Feasibility studies showed that LiFE was applicable in more impaired populations [40, 42] and implementable into restorative home care services [40]. However, modifications were required, including downgrading some exercises for safety reasons [40], increasing the script size and providing audio material to compensate for vision loss [42], and reducing the amount of paperwork [40]. On the same note, it remained unclear whether these adjustments were generic or specific, as no comparison to other programmes was made [40–42]. Feasibility studies partly confirmed positive effects on motor performance [40, 42] and PA [40] compared with RCTs. However, results were limited to before-after studies. Future RCTs are needed to evaluate the modified version of the LiFE programme found in this systematic review.

Interestingly, 1 study transferred LiFE to a group format. Participants established their individual activity plan during group sessions (and not during individual home visits). Based on this activity plan, participants practised LiFE in their everyday environment. Authors discussed that the presence of a team of trainers with different backgrounds, including sports science and psychology, had advantages for teaching the exercise and behavioural change component of LiFE. Social interaction, which has been reported beneficial for behavioural change in previous studies [20], was particularly valued by study participants. The study on group-LiFE was limited to a before-after study design and did not compare group-based with individual teaching.

Inducing behavioural change is a major aim of integrated training [41]. However, our review suggests that evidence for behavioural change and automatised integration of functional exercise into daily life is limited. Only 1 before-after study evaluated the behavioural change paradigm related to LiFE and reported positive changes in habit strength and related psychosocial determinants. This proof of concept study indicates that participants are generally able to perform integrated exercises subconsciously after 4 months of practice [41]. Results may suggest that the concept of behavioural change, which is typically implemented in other areas such as dietary behaviour [54, 55], dental hygiene [56, 57], or chronic pain [58], can be transferred to the area of functional exercise training. However, study results are limited to a 4-month period, without long-term follow-up, and a sample of young-old (mean age: 66 years) in which behavioural change is less challenging than in older adults [59].

A controlled trial compared a combined training programme (HBL) with a gym-based exercise training. Positive effects on functional performance and PA measured at post-test were sustained only in the HBL group. Results suggest that HBL is more effective in the long term compared with structured gym-based exercise training. HBL includes a behavioural change approach for fostering integration of training into daily routines, and results suggest that this leads to increased sustainability of effects. Results are in line with the findings from RCTs on LiFE training [26, 36] insofar as the HBL training also led to high sustainability of functional training effects in sedentary older adults. This might be attributed to the principle of training specificity (i.e., HBL is closely aligned to daily tasks [29]). In contrast, the gym-based exercise group performed rather artificial movements focusing on muscular strength, not being directly transferrable into functional daily life activity. Gym-based exercises have been found highly effective for improving lower-limb strength [45, 46], functional performance [46], and PA [46] in several studies. Maintaining training effects requires constantly visiting the gym. If this is difficult for participants, they have to find other ways of being physically active. In such cases, integrated training might be a complement to gym-based training as it allows to continue the training routine adopted during the intervention.

Limitations

Studies included used different designs (RCTs vs. NRS), intervention types (integrated vs. combined approaches), intervention aims (effectiveness, feasibility), and control groups (usual care; passive; gentle and flexibility exercises; structured exercises). This heterogeneity limited the comparability of identified articles and did not allow performing additional analyses such as meta-analysis. Additionally, a lack of quality rating for NRS and a high risk of bias in selection and performance contribute to a lower evidence level of NRS compared with RCTs. However, NRS reported important aspects about feasibility and acceptance (i.e., delivery mode, adaptability of approaches to different populations). These aspects are helpful for designing future RCTs on integrated training.

Conclusion and Recommendations for Future Research

This systematic review provides a comprehensive overview of the available evidence concerning integrated functional exercise training in older adults. Some studies reported advantages of this training concept compared to structured exercise training, including higher adherence, increased effectiveness for improving selected motor performances, and simultaneously increasing PA and reducing falls. However, the number of RCTs was low, and studies used different training concepts hampering their comparability. NRS provided some evidence about the effectiveness of the behavioural change concept and the feasibility of integrated training in impaired target populations. More RCTs are required for generating a higher level of evidence.

This review helps to inform the design of future trials. Understudied target groups are young-older adults ("baby boomer" generation) as well as substantially impaired populations, such as nursing home residents or rehabilitation patients. One study questioned the feasibility of implementing integrated training in cognitively impaired older adults due to the requirement of self-regulation imposed upon participants [25]. Future research may test specifically adjusted programmes to fully or at least partially sustain the idea of integrated training in this population. For example, we found concepts using nursing home staff for supporting the arrangement and management of integrated training [37–39]. Though it was not specifically evaluated whether this approach fostered adherence. Extending this concept, for instance by placing prompts on objects in institutionalised settings to reinforce automatisation of training, might be an avenue for successful implementation.

Teaching an integrated training to participants within a group was found to be feasible [41], but future studies need to evaluate whether the group format is similarly effective compared to individual teaching and potentially more cost effective.

RCTs in young-older adults aged 60 to 70 years are lacking. The EU project PreventIT (www.preventit.eu) is currently developing an integrated training programme for this population including ICT-based behavioural change paradigm.

In summary, we found that integrated training represents a promising alternative or complement to structured exercise programmes, but future studies are needed to evaluate the true potential of this concept.

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