Exercise Physiology

Effects of multicomponent exercise training on the intrinsic capacity in frail older adults: review of clinical trials

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Abstract - Aim: To review the effects of multicomponent exercise training on the domains of the intrinsic capacity of physically frail older adults: locomotion, vitality, cognition, psychological outcomes, and sensory function. **Methods:** The search for the studies was carried out in the MEDLINE, Cochrane CENTRAL, and PEDro databases, along with manual search, delimiting the period of publication as the last 10 years. The initial search identified 338 studies and 18 among them were analyzed qualitatively. **Results:** From the analysis of the included studies, great variability was evidenced between the intervention protocols, as well as between the results. As for the effectiveness of multicomponent exercise training, it has been shown to induce a positive effect on most of the analyzed outcomes. **Conclusion:** In summary, the present review suggests that multicomponent physical training can be effective to improve aspects of locomotion, cognition, and psychological aspects in frail older populations. Nevertheless, more studies are needed to specify the time needed to achieve such adaptations, the magnitude of these adaptations, and the design of the most appropriate training program for each outcome related to intrinsic capabilities.

Keywords: frailty, functional capacity, locomotion, cognition, quality of life, depression, vitality.

Introduction

Intrinsic capacity is a construct that can be understood as a multidimensional indicator related to functional status and is defined as the composite of all the physical and mental (including psychosocial) capacities that an individual can draw on at any point in time[1]. Among these capacities, which can be referred to as domains, five can be mentioned: locomotion, vitality, cognition, psychological and sensory functions[2]. These domains not only influence each other but are also influenced by genetic, environmental, and lifestyle factors[3].

As we age, our capabilities tend to decline, which can lead to a frailty outcome described as a decrease in functional reserve and resistance to stressors related to different physiological systems, which puts older people at increased risk of disability, hospitalization, and death induced by falls[4-7]. In addition, there is a strong association between cognitive status and muscle strength levels, and impairments in these components are associated with increased physical frailty[8-10]. However, the frailty condition can be potentially reversible and must be treated in order to avoid more unfavourable outcomes such as functional disability[11].

Considering the several aspects involved in the physical and mental capabilities of older people, and aiming for positive changes over time, an action plan designed for this population's needs, covering the different capabilities, should be highlighted[12]. In this sense, a multicomponent exercise intervention program that consists of strength and balance training and gait retraining seems to be an efficient strategy to improve gait, balance, and muscle strength, in addition to reducing the rate of falls and, consequently, maintaining functional capacity during aging[13,14].

Although the effects of a multicomponent exercise intervention (i.e., a combination of resistance, balance, and gait training) on functional capacity are well established, to the best of authors' knowledge, there is a lack of reviews about the effects of this type of intervention in all domains of the intrinsic capacity of older adults. Thus, the objective of this review is to gather evidence on the effects of multicomponent exercise training on the intrinsic capacity of frail older individuals, that is, in the domains of locomotion, vitality, cognition, psychological and sensory function.

Search strategy

A descriptive review of randomized clinical trials was performed. For the searches, the PICOT strategy was used. Studies with older participants with frailty syndrome and with institutionalized oldest old individuals were included. For frailty diagnosis, participants should meet at least one criterion proposed by Fried[15], or a score of ≤28/36 in the modified Physical Performance Test[16] (PPT), or identification as physically frail by the Frailty Index[17], or history of falls[18] (at least three falls in the last 12 months). We identified 204 studies and 18 were included in the review. Only studies that performed multicomponent exercise training including resistance training as an intervention were included because of the role of resistance training as a cornerstone to counteract the strength and power declines in frail older adults. Studies outside the English language or with nutritional intervention in the group of interest were not included.

The five domains that better define intrinsic capacity were considered as primary outcomes: a) locomotion, which refers to the individual's functional capacity, assessed by balance, mobility, muscle strength, and resistance tests; b) cognition, assessed by cognitive and motor tests with associated cognitive tasks; c) psychological health aspects, which include mood and sociability, assessed by the quality of life and depressive symptoms questionnaires; d) vitality, which refers to the balance between energy intake and use, assessed through body composition; and e) sensory functions, assessed by vision and hearing tests. These five domains interact closely with each other[1] and are related to reduced physical and mental capabilities, and could be used to independently predict mortality and care dependence in older population[19].

Locomotion was assessed using balance tests found in the Short Physical Performance Battery (SPPB)[20-22], postural balance test in the Physiological Profile Assessment (PPA)[23,24], Berg Balance Scale (BBS)[25], single-leg stance test[18], FICSIT-4 tests[26], balance test in the Tinetti Assessment[20], Stork Balance Stand Test[27], Timed-up-and-go (TUG)[18,24-26,28,29], usual gait speed tests[20-23,26-31], maximum gait speed test[28,32], ankle heel rise test[18], 10 times sit and stand test[29], stair climbing test[29], 6-min walking test[20,25,28], SPPB[20-23], PPT[20], modified PPT[28] and gait test in the Tinetti Assessment[20].

Cognition was assessed with the Mini-Mental State Examination (MMSE)[20,28,31], Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)[33], abstract verbal reasoning tests, episodic memory, processing speed, working memory and executive functions[28], gait speed test associated with verbal and arithmetic tasks and TUG associated with verbal and arithmetic tasks[26].

Psychological aspects were assessed with SF-12[30,34], SF-36[25,27], EuroQol (EQ-5D)[20,24], EuroQol Visual Analog Scale (EQ-5D VAS)[21], Systemic Quality of Life Inventory (Qol SI)[28], Quality of Life Assessment developed by the World Health Organization (WHOQOL-BREF)[31], Geriatric Depression Scale (GDS-15)[18,20,22,24,30,31,35,36] and Montgomery-Åsberg Depression Rating Scale (MADRS)[36].

Vitality was assessed with the Body Mass Index (BMI)[20,22,32], body mass, lean mass[20,22], and muscle cross-sectional area[26]. Regarding the sensory functions, visual contrast sensitivity was assessed with the Melbourne Edge Test[23,24].

The search was performed using the following electronic databases: MEDLINE (via Pubmed), Cochrane CENTRAL, and PEDro, in addition to a manual search in the references of published studies.

Effects of multicomponent exercise programs on different intrinsic capacity domains

The results found in the different domains of intrinsic capacity are summarized in Table 1, and the characteristics of resistance training as the main component of the interventions, as well as the adverse effects, are summarized in Table 2.

Table 1 - Characteristics of the included studies: sample size, mean age, intervention time, training protocols (intervention), and outcomes (main results).

Authors	N, age	Intervention period	Intervention	Main results
Ng, et al. 2015	246, 70	24 weeks	MEP: ST + BT + GT	↑ Fast gait speed (3, 6, and 12 months)
				= BMI (3, 6, and 12 months)
Cadore, et al. 2014	24, 92	12 weeks	MEP: ST + BT + GT	= Usual gait speed
				= Gait speed (associated with cognitive tasks)
				↓ TUG*
				↓ TUG* (associated with cognitive tasks)
				↑ Balance (FICSIT-4)
				↑Quadriceps femoris and knee flexor muscles cross-sectional area

(*continued*)

Table 1 - continued

Authors	N, age	Intervention period	Intervention	Main results
Hsieh, et al. 2019	319, 72	24 weeks	MEP: ST + BT + FLEX + AT	= Usual gait speed = Depressive symptoms (GDS-15) = Quality of life (SF-12)
Langlois, et al. 2013	72, 61-89	12 weeks	MEP: ST + FLEX + BT + AT	= Gait speed = TUG ↑ Modified PPT ↑ 6-minute walking ↑ Cognition (in 50% of the tests) = MMSE ↑ Quality of life (Qol SI)
Tarazona-Santabalbina, et al. 2016	100, 80	24 weeks	MEP: ST + FLEX + BT + AT	= Gait Test (Tinetti Assessment) = Balance (Tinetti Assessment) ↑ PPT ↑ SPPB ↑ Cognition (MMSE) ↓ Depressive symptoms* (GDS-15) ↑ Quality of life (EQ-5D) = Anthropometric measurements
Sadjapong, et al. 2020	64, 78	24 weeks	MEP: ST + BT + AT	↓ TUG* (12 and 24 weeks) ↑ Balance (BBS, 12 and 24 weeks) = Maximum aerobic power ↑ Quality of life (SF-36, 12 weeks, only on the physical component) = Quality of life (SF-36, 24 weeks)
Ng, et al. 2018	246, 70	24 weeks	MEP: ST + BT + GT	= Cognition (RBANS, 6 and 12 months)
Ng, et al. 2017	246, 70	24 weeks	MEP: ST + BT + GT	↓ Depressive symptoms* (GDS-15, 6 months) = Depressive symptoms (GDS-15, 3, and 12 months)
Cameron, et al. 2013	216, 83	12 weeks	MEP: ST + BT	= Usual gait speed (12 weeks) ↑ Usual gait speed (12 months) = Balance (12 weeks) ↑ Balance (12 months) = SPPB (12 weeks) ↑ SPPB (12 months) = Depressive symptoms (GDS-15, 12 weeks, and 12 months) = Quality of life (EQ-5D VAS, 12 weeks and 12 months)
Fairhall, et al. 2014	241, 83	12 weeks	MEP: ST + BT	= Gait speed (12 weeks) ↑ Gait speed (12 months) = SPPB (12 weeks) ↑ SPPB (12 months) = Balance (12 weeks) ↑ Balance (12 months) = Visual sensitivity to contrast

(*continued*)

Table 1 - continued

Authors	N, age	Intervention period	Intervention	Main results
Serra-Rexach, et al. 2011	40, 92	8 weeks	MEP: ST + AT	= Gait speed
				= TUG
				= Stair climb test
				= 10 times sit-and-stand test
Zech, et al. 2012	69, 77	12 weeks	MEP: ST (or POW) + BT	↑ SPPB (12 weeks)
				= SPPB (24 and 36 weeks)
				= Gait speed (12, 24, and 36 weeks)
				= Anthropometric measurements (12, 24, and 36 weeks)
Kim, et al. 2020	605, 77	12 weeks per year (27 months)	MEP: ST + BT + FLEX + AT	↑ Gait speed (only the frailest older adults)
				↑ Cognition (MMSE)
				= Depressive symptoms (GDS-15)
				↑ Quality of life (WHOQoL-BREF)
Boström, et al. 2016	186, 85	4 months	MEP: ST + BT	= Depressive symptoms (GDS-15 and MADRS, 4 and 7 months)
Jeon, et al. 2014	70, 69	12 weeks	MEP: ST + BT	= Balance (single leg stance test)
				↓ TUG*
				↑ Lower limb endurance
				↓ Depressive symptoms* (GDS-15)
Lee, et al. 2013	616, 76	12 weeks (8 training weeks)	MEP: ST + BT + AT	= Visual sensitivity to contrast
				↓ TUG*
				↑ Balance (body sway test)
				↓ Depressive symptoms* (GDS-15)
				= Quality of life (EQ-5D)
Kwon, et al. 2015	89, 77	12 weeks	MEP: ST + BT + GT	= Gait speed (12 and 24 weeks)
				= Balance (12 and 24 weeks)
				↑ Quality of life (↑ only in "mental health" do SF-36)
				= Quality of life (24 weeks)
Giné-Garriga, et al. 2013	51, 84	12 weeks	MEP: ST + BT	↑ Quality of life (SF-12, 12, and 36 weeks)

MEP, multicomponent exercise program; ST, strength training; BT, balance training; POW, power training; GT, gait training; AT, aerobic training; FLEX, flexibility training; BMI, Body Mass Index; TUG, timed-up-and-go; GDS-15, 15-item Geriatric Depression Scale; SF-12, 12-item health status questionnaire; SF-36, 36-item health status questionnaire; PPT, Physical Performance Test; Qol SI, Systemic Quality of Life Inventory; SPPB, Short Performance Physical Battery; MMSE, Mini-Mental State Examination; EQ-5D, EuroQoL Group Systemic Quality of Life Inventory; EQ-5D VAS, EuroQol Group Visual Analogue Quality of Life Scale; BBS, Borg Balance Scale; WHOQoL-BREF, Quality of Life Assessment developed by the World Health Organization; RBANS; Repeatable Battery for the Assessment of Neuropsychological Status; MADRS, Montgomery-Åsberg Depression Rating Scale. *score/ shorter times indicate better results.

Effects on locomotion

Three studies found significant improvements in usual gait speed following 12 and 27 months[21-23,31] and one study found significant improvements in fast gait speed[32]. However, some studies found no significant differences in gait speed after intervention lasting from 2 to 9 months[21-23,26,27,29,30]. Only one study used the Tinetti Assessment and found significant improvements in the gait test after 24 weeks[20].

Four studies found significant improvements in TUG after periods ranging from 8 to 24 weeks[18,24-26], while two studies found no significant improvement at 8 and 12 weeks[28,29]. One study found significant improvement in the 6-minute walk test after 12 weeks[28] and one study found no improvement at 12 and 24 weeks[25]. Five studies found significant improvements in the balance after periods ranging from 12 weeks to 12 months[21,23-26]. However, five studies found no significant improvement in periods between 12 and 24 weeks[18,20,21,23,27].

Only one study observed significant improvements in the ankle heel rise test at 12 weeks[18].

Table 2 - Training characteristics: weekly frequency, session time, strength training volume, strength training intensity, and adverse effects.

Authors	Weekly frequency	Session time	ST volume (sets x repetitions)	Intensity	Adverse Effects
Ng, et al. 2015	2	90 min	1x8-15	60-80% 1RM	3 participants reported pain
Cadore, et al. 2014	2	40 min	2x8-10	40-60% 1RM	3 participants related drug complications; 5 participants died (deaths not related to the protocol)
Hsieh, et al. 2019	3-7	5-60 min	-	-	-
Langlois, et al. 2013	3	60 min	-	-	-
Tarazona-Santabalbina, et al. 2016	5	65 min	1-3x8-10-15-30	25-75%1RM	-
Sadjapong, et al. 2020	3	60 min	2-3x8-10-12	75-90%1RM*	-
Ng, et al. 2018	2	90 min	1x8-15	60-80%1RM	3 participants reported pain
Ng, et al. 2017	2	90 min	1x8-15	60-80%1RM	3 participants reported pain
Cameron, et al. 2013	3-5	-	-	-	2 participants reported back pain
Fairhall, et al. 2014	3-5	20-30 min	-	-	1 participant reported drug complications; 1 participant reported pain
Serra-Rexach, et al. 2011	3	45-50 min	2-3x8-10	60-80%1RM	-
Zech, et al. 2012	2	60 min	2x6-15	10-16 Borg Scale	1 participant reported exacerbation of osteoarthritis; 1 participant reported dizziness
Kim, et al. 2020	7	-	3x5	-	-
Boström, et al. 2016	3	45 min	8-15 repetições	-	-
Jeon, et al. 2014	3	40-60 min	-	-	No adverse effects
Lee, et al. 2013	1	50-60 min	-	-	No adverse effects
Kwon, et al, 2015	1	60 min	Access unavailable	Access unavailable	-
Giné-Garriga, et al, 2013	2	-	1-2x6-8-15	12-14 Borg Scale	No adverse effects

ST, strength training; 1RM, one-repetition maximum. *Intensity is defined by the color of the elastic band.

Two studies found significant improvements in functional capacity, assessed with a battery of tests, at 12 weeks[22,28]. However, two studies found no significant differences at 12 weeks[21,23]. Two studies found stability in the SPPB score of the intervention group, with a significant difference compared to the control group, which declined in 12 months[21,23].

Based on the searched literature, we observed great variability in the results of several functional tests. In periods shorter than 1 year, in general, the interventions did not improve usual gait speed, while most studies observed improvements in TUG in periods ranging from 12 to 24 weeks[18,24-26]. These findings suggest some gait tests may be more sensitive in order to detect significant changes in the gait ability of frail individuals.

Regarding balance performance, the results were quite conflicting up to 24 weeks of intervention. In the long-term (i.e., 1 year), it seems that multicomponent exercise training promotes significant improvements in the balance of frail older adults[21,23]. Nevertheless, the same may not be observed in the short term. Notwithstanding, the inclusion of balance training remains relevant, independent of intervention duration since balance appears to be improved when balance exercises are added to the exercise interventions[13]. Indeed, four studies found significant increases in up to 6 months of intervention[24-27].

In the six-minute walking test, the controversial findings may possibly be explained by the training prescription, since one study prescribed short duration sessions (20 min) at a moderate intensity (12-13 in the Borg's Subjective Perception of Effort Scale)[25] and did not find significant improvements. It is important to emphasize that it may be necessary to perform resistance exercises and gait retraining before starting the endurance training, especially in frail older adults who have poor gait ability[37]. In fact, in a recent International Consensus for the prescription of exercises for older adults, it was established that the improvement in locomotion should be preceded first by improvements in the ability to stand up, followed by an improvement in the ability to remain in that position. (i.e., balance)[38].

Regarding the functional test batteries, all studies found positive results in at least one of the assessments composing these batteries[20-23,28]. Overall, the findings suggest that multicomponent exercise training is effective to improve aspects related to functionality and locomotion both in the short term and in the long term.

Effects on cognition outcomes

Four studies found significant improvements in cognitive function after periods ranging from 12 weeks to 27 months[20,26,28,31]. Among these, one study found significant improvements in TUG associated with arithmetic and verbal tasks after 12 weeks of intervention[26]. However, the same study found no significant increases in usual gait speed associated with arithmetic and cognitive tasks over the same period.

One study found significant increases in processing speed, working memory, and executive functions after 12 weeks of intervention[28]. Nevertheless, no significant differences were found for the tests of abstract verbal reasoning, episodic memory, and MMSE. Two studies found significant increases in the MMSE after intervention periods of 24 weeks and 27 months, respectively[20,31]. Only one study found no significant increments in RBANS after 6 and 12 months of intervention[33].

The effects on cognition were not unanimous regarding the effectiveness of multicomponent training, but most studies showed significant improvements in at least one cognitive test performed in the short- or long-term[20,26,28,31]. These findings suggest that multicomponent exercise training can be an effective intervention in improving cognition, even without cognitive training as part of the intervention. These results can be supported by García-García and Larrión-Zugasti[39], which suggests that cognitive impairment and muscle strength are directly associated. In this sense, it can be suggested that effective interventions to improve physical function in frail older people may be also beneficial in providing improvements in older individuals with cognitive impairment.

Effects on psychological outcomes

Six studies showed significant improvements the in quality of life of frail individuals after periods ranging from 12 weeks to 27 months[20,25,27,28,31,34]. However, five studies found no significant improvement in intervention periods ranging from 12 weeks to 12 months[21,24,25,27,30]. Four studies found significant improvements in depressive symptoms of frail individuals at interventions ranging from 12 to 24 weeks[18,20,24,35]. Nevertheless, five studies found no significant improvement after periods ranging from 12 to 27 months[21,30,31,35,36].

The results regarding quality of life were not unanimous. Six of the nine studies showed significant improvements in at least one of the components of the assessments[20,25,27,28,31,34]. Therefore, we can say that multicomponent exercise training can be an effective strategy to improve the quality of life in frail older, although further studies are needed to consolidate this evidence. The variability of interventions and participants, including sociocultural issues, limited the analyses regarding the characteristics of a more effective training model on psychological outcomes.

Considering depressive symptoms, three studies evaluated the effects of multicomponent exercise training for one year or longer and found no significant improvement[21,31,33], suggesting that multicomponent exercise training alone, without specific psychotherapeutic intervention, does not seem to be effective in decreasing the depressive symptoms in frail older adults in the long-term. In the short term, the results are conflicting. Four out of eight studies that performed assessments between 12 and 24 weeks found significant improvements[18,20,24,35]. Interestingly, changes in gait speed and exhaustion were significantly associated with changes in the GDS scale[35], suggesting that promoting changes in these outcomes may be relevant to attenuate depressive symptoms in this population. This explains, in part, how multicomponent exercise training can contribute to the reduction of depressive symptoms. We should mention that performing training in groups and at home is a factor that can difficult the outcomes analysis since social interaction can also contribute to the reduction of depressive symptoms[40].

Effects on vitality and sensory functions

No studies found a significant difference in BMI, body mass, or lean body mass after periods ranging from 12 weeks to 12 months in frail individuals[20,22,32]. In contrast, a multicomponent exercise program composed of explosive resistance training (i.e., maximal intentional speed during concentric muscle actions), balance training, and gait retraining significantly improved lower-limbs muscle mass as well as muscle fat infiltration in frail nonagenarians individuals at 12 weeks[26].

The absence of further results regarding body composition outcomes in this population may be explained by our exclusion criteria, which excluded training protocols associated with nutritional interventions as well as few studies assessed outcomes related to body composition. The World Health Organization[1] suggests that nutrition-focused interventions aimed at restoring metabolic balance are capable of delaying care dependence, reversing frailty, and potentially improving intrinsic capacity.

No study found significant improvement in sensory functions with the contrast sensitivity test after 12 weeks and after 12 months in this population[23,24]. In addition, we could not find studies that could justify improvements in vision through physical training, that is, no biological plausibility was found to support possible increases in the test used in one study (visual sensitivity to contrast). Thus, there is a lack of evidence that multicomponent exercise training can improve sensory functions.

Limitations

This review has some limitations that should be acknowledged. Among the different included studies, different frailty criteria were used for individuals' inclusion. In addition, the presence of cognitive decline or dementia symptoms was not an exclusion criterion, which contributes to high heterogeneity in the individuals' characteristics among the studies. Moreover, there was also high heterogeneity among different multicomponent interventions, with studies applying different intensities, volumes, and weekly frequencies of training as well as different ways of intensity control. Nevertheless, it is worth noting that these characteristics make it possible to compare the effects of different multicomponent exercise training protocols on different and relevant outcomes for the promotion or maintenance of the independence of frail older people, both in the short and in the long term, which can be understood as a strength of this review.

Conclusion and implications

This descriptive review suggests that multicomponent exercise interventions including resistance training can be effective in improving locomotion, cognition, and psychological aspects in frail older adults. Taken together, it is possible to infer that exercise programs with session durations ranging from 20 to 90 minutes, including resistance exercises performed 2 to 3 times per week, at intensities between 30 and 80% of 1RM (including explosive muscle actions with moderate loads), 2 to 3 sets per exercise, in combination with balance and gait retraining induce improvements in most of the outcomes associated with intrinsic capacity. Further studies are warranted in order to determine the most appropriate training program design for each component considering the functional status and individual characteristics of the participants.

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