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Combined Effects of Diet and Exercise or Diet Alone to Improve Physical Function in Community-Dwelling Older Adults: A Systematic Review of the Literature

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Abstract

This systematic review and meta-analysis examines the effectiveness of combined diet (not limited to caloric restriction) and exercise interventions, and diet interventions alone to improve physical function in community-dwelling older adults. Randomized clinical trials and observational population-based studies of community-dwelling older adults were selected through comprehensive bibliographic searches in Medline (up to September 2014). Included trials had to assess performance- based measures of physical function such as strength, balance, mobility and gait, and diet measured as diet indexes or food intake. Seven studies were included. Meta-analysis was performed with the inverse variance method under the random effects models. Combined exercise and diet interventions, when compared with control or diet interventions alone, were shown to improve walking speed and performance on the Short Physical Performance Battery (SPPB), although SPPB results failed to show clinical significance. No consistent effect was observed for balance outcomes. Although exercise interventions are known to improve physical function outcomes, based on current data, it is not possible to affirm that a combination of diet and exercise interventions can further improve physical function. The evidence comparing different patterns of diet is scarce, and it is not possible to pinpoint which diet intervention is the most effective.

Keywords Diet, Exercise, Physical activity, Older adults, Systematic review, Meta-analysis, Physical function

Introduction

Older adults aged 65 and over are the fastest growing segment of the world's population [1]. Although prolongation of life remains an important public health goal, of even greater significance is the preservation of the capacity to live independently and to function well during late life. The normal physical aging process is characterized by muscle fiber atrophy and reduction in skeletal muscle mass [2], associated with concomitant reductions in muscle strength [2, 3]. The peripheral sensory systems that are responsible for maintaining posture control also deteriorate with aging [4], and the ability to maintain control of posture is important for the successful performance of most daily activities. Tinetti et al. [5] demonstrated that decline in muscle weakness, impaired balance, and reduced mobility might be risk factors for functional dependence.

Recently, physical activity has been discussed as an important step on the pathway to disability [6]. The benefits of exercise in delaying physical dependence in an elderly population have long been recognized [7, 8], and recent randomized controlled trials (RCTs) and systematic reviews have shown that exercise seems to be beneficial in improving physical functions, such as sit-to-stand performance, balance, agility, and gait in older adults [9–13, 14, 15, 16]. In a recent publication, the Lifestyle Interventions and Independence for Elders (LIFE) multicenter RCT showed with a large sample of community-dwelling elders and over 2.6 years of follow-up, that a structured, moderate-intensity physical activity intervention significantly reduced major mobility disability [17].

Epidemiological studies conducted in different countries have shown that adherence to a healthy diet pattern (measured using diet indexes) is associated with longer survival and im- proved quality of life, lower risk of chronic degenerative dis- ease, reduced cardiovascular and cancer mortality, and lower risk of cognitive decline and dementia@@ [18–23, 24, 25, 26, 27], even in older adults [28, 29, 30]. The Mediterranean diet (MedDiet) defined as a combination of several potentially protective foods and nutrients, such as fruit and vegetables, fish, monounsaturated fatty acids, vitamin B12 and folate, antioxidants, and moderate amounts of alcohol [19, 31–35, 36], has been the most cited diet pattern associated with im- proved life expectancy and quality of life [24, 36]. A prospective population-based study of community-dwelling elderly people showed that high adherence to a MedDiet was associated with a slower decline of mobility over time [37]. Another prospective study showed that walking speed over 8 years was faster in those with higher MedDiet adherence at baseline, suggesting a long-term effect of diet on mobility performance with aging [38] (the aforementioned studies' description is included in Table 1). Poor nutritional status, resulting from inadequate dietary intakes of energy and/or protein, may contribute to the development of sarcopenia and aggravate the expected age-related loss of muscle mass and function [39, 40]. Most research studies assessing the effects of a diet intervention (excluding diet supplementation) on physical function use prospective population-based de- signs excluding strong methodological designs such as RCTs, likely because of the resources (i.e., money and time) needed to conduct an intervention over a long enough period of time to see change in the outcome of interest. Therefore, systematic reviews assessing the effects of diet and a combi- nation of diet and exercise interventions to improve physical function have yet to be published.

This systematic review aims to integrate the most current evidence on the effect of combined exercise and diet interventions or diet interventions alone on improving performance based measures of physical function in community dwelling older people. Diet interventions were based on dietary modification and not specifically looking at diets causing weight loss. Specifically, the authors aimed: (a) to examine the effectiveness of combined diet and exercise interventions including RCTs and prospective population-based studies to improve physical function in community-dwelling older adults; and (b) to examine the effectiveness of diet interventions, excluding diet supplementation, to improve physical function in community-dwelling older adults.

Methods

Study Selection and Data Extraction

We performed a systematic review of existing literature following the Cochrane methodology [41] and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology for reporting [42].

We included RCTs, cohort studies, and cross-sectional de- signs assessing the effect of a structured diet, or a combination of diet and a structured physical activity intervention to im- prove physical function in older community-dwelling adults, compared to a control group. The control could be no intervention or to receive general advice regarding physical activity and/or diet. Inclusion criteria were: participants 65 years of age and older; with and without non-communicable diseases, and living in the community. We excluded studies where participants presented with disability (e.g., advanced disability in performing activities of daily living (ADL), dementia, or end- stage disease), were institutionalized or in hospital settings.

The studies had to present outcome data for any of the primary outcomes. Primary outcomes in the review were performance-based measures of physical function including physical performance scales (e.g., Short Physical Performance Battery, SPPB) or measures of mobility, gait, muscular strength, balance or endurance (aerobic capacity), and diet measured as diet indexes or food intake, excluding those articles evaluating supplements intake.

A literature search was conducted in Medline up to September 2014, in order to include all the evidence available. We utilized MeSH terms, MeSH sub-hierarchy terms, thesaurus synonyms, and thesaurus words in the search strategy.

Table 1 Descriptive information of selected trials

Author. Study design	Age (years) Gender (F=female; M=male)	Purpose. Intervention program and subjects	Outcome measures	Findings
Rydwik et al. [46] 2008 RCT Diet and exercise	Age (mean): 83.3 Gender: 56 % F	Purpose: describe the impact of physical and nutritional intervention program for frail community-dwelling elderly people. Program: participants were randomized to physical training program (aerobic, muscle strength, balance), a nutritional intervention program (individually targeted advice and group sessions), a combination of both or control group. 12-weeks intervention, 6 months follow-up. Subjects: Training and nutrition (N=25); Nutrition (N=25); Training (N=23); Control group (N=23)	Tandem stance One leg stance Modified figure eight Step test Chair-stand Step-ups Timed up and go test Maximal walking speed	The mean compliance rate with the physical training program was 65 %. Physical training significantly increased lower extermity muscle strength compared with nutrition alone at the first follow-up.
Milaneschi et al. [37 • •] 2011 Cohort study Diet	Age (mean): 74.1 Gender: 55.6 % F	Purpose: examine whether adherence to a Mediterranean-style diet has positive effects on mobility. Program: lower extremity function was measured at baseline, and at the 3, 6 and 9-year follow-up. Subjects: Mediterranean Diet Score; ≤3 (N=253); 4−5 (N=408); ≥ (N=274)	Short physical performance battery (SPPB)	At baseline, higher adherence to Mediterranean diet was associated with better lower body performance. Participants with higher adherence experienced less decline in SPPB score, which was of 0.9 points higher (P<.0001) at the 3-year follow-up, 1.1 point higher (P=0.0004) at the 6-year follow-up, and 0.9 points higher (P=0.04) at the 9-year follow-up compared to those with lower adherence.
Villareal et al. [48] 2011 RCT Diet and exercise	Age (mean): 69.7 Gender: 62.7 % F	Purpose: to determine the independent and combined effects of sustained weight loss and regular exercise on physical function, body composition and quality of life in obese older adults. Program: 52-week study. A group that participated in a weight-management program (diet group), a group that received exercise training (exercise group) and a group that received both interventions. 6 and 12 moth follow-up. Subjects: Diet (N=27); Exercise (N=26); Diet-Exercise (N=28); Control group (N=27)	Physical performance test (PPT) Functional Status Questionnaire (FSQ)	The score on the PPT increased more in the diet-exercise group than in the diet group or the exercise group (from baseline of 21 vs. 12 and 15 %, respectively). The score on the FSQ increased more in the diet-exercise group than in the diet group (P<0.001). Body weight decreased by 10 % in the diet group and by 9 % in the diet-exercise group, but did not decrease in the exercise group or the control group (P<0.001).
Shahar et al. [38 • •] 2012 Cohort study Diet and exercise	Age (mean): 74.5 Gender: 47.9 % F	Purpose: to determine the association between Mediterranean diet (MedDiet) score and 20-m walking speed over 8 years. Program: participants with dietary assessment at year and 20-m usual walking speed data were repeated in participants who survived 10 years.	20 m walking test	Individuals in the highest MedDiet adherence group were more likely to have lower body mass index, higher energy intake, and greater physical activity (P<.05). Usual and rapid 20-m walking speed were highest in the high MedDiet adherence group than in other groups. Over 8 years, usual and rapid 20-m walking speed declined in all MedDiet adherence groups.

Table 1 (continued)

Author. Study design	Age (years) Gender (F=female; M=male)	Purpose. Intervention program and subjects	Outcome measures	Findings
		Subjects: Mediterranean Diet Score; Low (0–2) *N*=809; Middle (3–5) *N*=1303; High (6–9) *N*=113		
Neville et al. [44] 2013 RCT Diet	Age (mean): 71 Gender: 65.5 % F	Purpose: examine the effect of increased fruit and vegetable(FV) consumption on measures of muscle strength and physical function. Program: participants were randomised to increase FV consumption to at least 5 portions/day or to follow their normal diet (2 portions/day) for 6, 12 and 16 weeks. Subjects: 2 portions/day (*N*=39); 5 portions/day (*N*=41)	Short physical performance battery (SPPB)	The five portions per day group showed greater change in daily FV consumption compared to the two portions per day group ($P<0.001$). No significant differences were evident in change in physical function between the two groups.
Radavelli-Bagatini et al. [45 • •] 2013 Cross-sectional Diet	Age (mean): 75.2 Gender: 100 % F	Purpose: evaluate the association of dairy intake with body composition and physical performance. Program: women were categorized according to tertiles of dairy intake: tertile 1 (≤1.5 servings/day), tertile 2 (1.5 to 2.2 servings/day) and tertile 3 (≥2.2 servings/day). Subjects: Tertile 1 (*N*=449); Tertile 2 (*N*=512); Tertile 3 (*N*=495)	Timed up and go test	Women in the third tertile of dairy intake had significantly greater whole body lean mass (P=0.0001) and appendicular skeletal muscle mass (P=0.002), greater hand-grip strength (P=0.02), and 26 % lower odds for a poor timed up and go test (P=0.04).
Schilp et al. [47] 2013 RCT Diet	Age (mean): 80.5 Gender: 64.35 % F	Purpose: determine the effects of a dietetic treatment in older, undernourished, community-dwelling individuals. Program: participants were assigned to the Intervention (referral to and treatment by a trained dietitian) or control group (no referral). 3 and 6 months follow-up. Subjects: Control group (*N*=74); intervention group (*N*=72)	Short physical performance battery (SPPB)	No treatment effect was found on the primary outcomes body weight, physical performance, and hand-grip strength.

Keywords used were: older adult, diet, physical activity, and physical function. The search terms and strategy used to identify the papers are outlined in Appendix 1 and with no restriction regarding the year of publication. The search was not restricted by language.

The titles and abstracts (when available) of all reports identified through the electronic searches were scanned independently by four review authors (MGG, NGT, BRV, and EVG) to identify potentially eligible studies using the inclusion criteria. For studies appearing to meet the inclusion criteria, or for which insufficient data were available in the title and abstract to make a clear decision, final inclusion or exclusion was decided through independent assessment of the full report by four authors, followed by discussion and consensus. Information relevant to the topic (design, methodological quality indicators, study purpose, treatment, participants, participation outcome measure(s), and findings) was extracted independently by two authors (BRVand EVG) who then com- pared and discussed any discrepancies. Reasons for exclusion of studies rejected at this or subsequent stages were recorded.

Statistical Methods

A validity assessment of all included trials was conducted to inform about the interpretation of results and the formulation of conclusions in the review. However, given the low number of studies included and the differing design between them (e.g., RCT and observational studies), we did not conduct a sensitivity analysis by risk of bias. Likewise, the low number of included studies prevented us to conduct a formal publication bias assessment through statistical methods. It is recommended that formal publication bias assessments should be conducted when the review includes ten or more trials.

We assessed the risk of bias in each RCT [41]. For each trial, we assessed the risk of bias of the following domains: random sequence generation, allocation concealment, blinding of assessments, incomplete outcome data, and selective outcome reporting. For each trial, an overall assessment of risk of bias was derived as low, high, or unclear based on the previous assessments. If any domain was at high risk of bias, the trial was considered to be at high risk of bias. Trials with four or five domains at low risk of bias were considered to be at low risk of bias. Otherwise, risk of bias of the trial was considered to be unclear.

The quality of the cross-sectional and cohort studies included in the review was assessed with the Newcastle–Ottawa Scale tool. In this tool, each study is appraised on eight items, categorized into three groups: the selection of the study groups, the comparability of the groups, and the ascertainment of either the exposure or outcome of interest for case–control or cohort studies, respectively [43].

Effect was measured with risk ratios for dichotomous out- comes, and with mean differences for continuous outcomes. If there was low clinical heterogeneity between studies in terms of populations, interventions, and outcomes, pooled estimates of effect were obtained. The analyses were stratified by com- parison into diet versus control, and combined diet and physical activity versus control. Meta-analysis was conducted ap- plying the inverse-variance method under a random-effects model. Statistical heterogeneity was assessed through I^2, considering values over 50 % as a sign of moderate to high heterogeneity. There is significant clinical heterogeneity in our systematic review in terms of design, interventions and out- comes. However, this situation is common when exploring interventions that may be difficult to standardize, such as non-pharmacological, complex, or multifactorial interventions. The quantitative accuracy of meta-analysis is suggested to make it a superior option to simple narrative interpretation without synthesis [44], given that its limitations are properly acknowledged.

Results

Description of Included Studies

The systematic search retrieved 1,600 citations, of which 1, 590 were excluded because of an exclusion criteria or because they evaluated standalone exercise interventions. As mentioned in the "Methods" section, we decided not to include studies that assessed standalone exercise interventions (*n*= 107) as there were recent systematic reviews available in the literature. Ten potential full texts were obtained to further ap- ply the inclusion/exclusion criteria. Finally five studies were included in the review [45, 46–49]. In addition, two publications were identified in the references and thus, incorporated for inclusion/exclusion analysis. Both of them were included in the final selection [37, 38], being the prospective cohort studies. The flow chart of references and the causes of exclusion are presented in Fig. 1.

The overall risk of bias for the included RCT was low in three trials [45, 48, 49]. The other trial had a high risk of bias [47]. According to the Ottawa–Newcastle scale, one study showed a high quality methodology [38], one showed an unclear quality [37], and the cross-sectional study [46] showed a low quality methodology.

We faced some challenges in assessing inclusion criteria: we included trials whose participants had moderate dependence in mobility, but we excluded trials on participants with dependence in basic ADL.

Type of Studies

Two of the selected publications reported data from prospective cohort studies [37, 38], one from a cross-sectional study [46], and the remaining four were randomized controlled clinical trials [45, 47–49]. Table 1 shows the main characteristics of the selected studies.

Ages from four studies were 65 years or older [37, 45, 48, 49] and the remaining three included participants over the age of 70 years [38, 46, 47]. The sample size from the clinical trials were between 80 and 146 participants [45, 47–49], while from the cross-sectional study and the prospective cohort studies were from 935 to 2,225 participants [37, 38, 46]. Descriptive information of the selected studies is present- ed in Table 1.

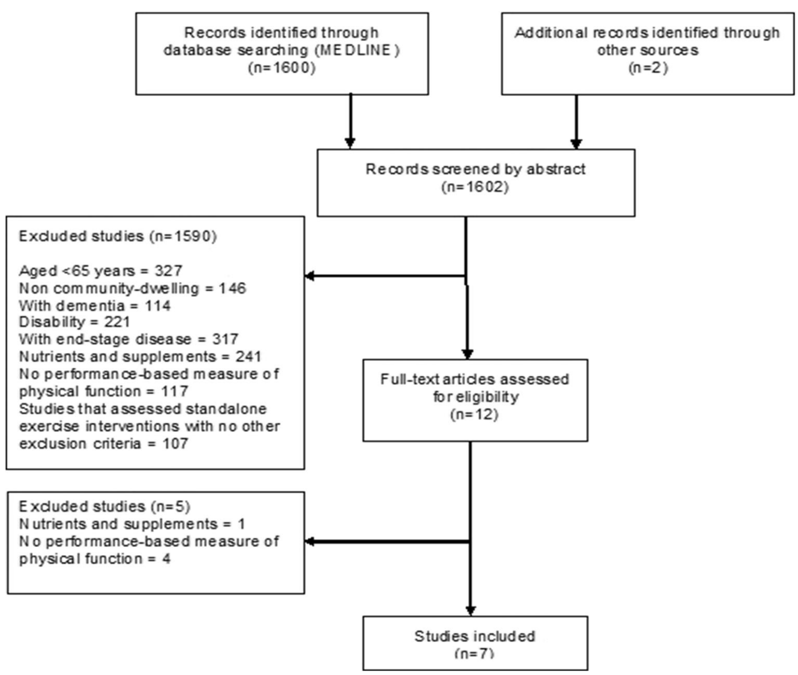

Fig. 1 Flowchart following PRIS MA guidelines. PRISMA preferred reporting items for systematic reviews and meta- analyses

Description of Outcomes Assessed

Two observational studies [37, 38] evaluated the diet by measuring adherence to the Mediterranean diet using the diet index developed by Trichopoulou et al. [27],and the third one measured dairy intake [46]. Physical activity (PA) was measured with questionnaires that evaluated PA over 1 year [37••] or in a 1-week period [38].

There was high heterogeneity in the outcomes assessed in the included trials. Functional capacity was measured with the Short Physical Performance Battery [45, 48], the modified Physical Performance Test [49], the Timed Up and Go test [46], strength measurement tools [45, 46–48], the chair stand test [37, 47], a walking test [37, 38, 47], and other measurements of balance and mobility [47].

All clinical trials assessed outcomes at the end of the intervention, and only one trial reported longer follow-up data at 6 to 12 months [49]. The follow-up of the cohort studies was 3, 6 and9 [37], and 8 years [38]. The average study duration is presented in Table 1.

Description of Interventions

Four studies evaluated the combined effect of diet and exercise [47, 49] or diet and physical activity [37, 38] on physical function in the elderly. Three studies evaluated the effect of diet alone on the health outcome [45, 46, 48], one evaluated the overall diet [48], one evaluated fruit and vegetable intake [45], and in the other was the outcome of interest for diet [46] (see Table 1).

The interventions assessed in the included studies were extremely heterogeneous. Diet interventions consisted of a balanced diet producing an energy deficit of 500 to 750 Kcal plus behavioral therapy [49], a personalized diet counselling and group session education [47], and an increase in fruit and vegetable intake from less than two to five daily portions [45]. In two studies, individuals received nutritional supplements in addition to a dietary modification [48, 49].

The exercise interventions studied differed in content (resistance, stretching, strength, flexibility, and balance), setting (facility/home), delivery (individual/group), duration, and frequency. One study prescribed 60 min of exercise (emphasizing aerobic capacity, muscle strength, and balance) twice a week during 12 weeks [47] and another one prescribed 90 min of exercise three times per week (including aerobic exercises, resistance training, and flexibility and balance) for 52 weeks [49] (see Table 1 for more details).

Efficacy of Diet Alone or Combined with Exercise on Physical Function Outcomes

Statistical pooling could only be conducted for gait speed, SPPB, and balance outcomes. The effects of combined exercise and diet interventions and diet interventions alone by gait speed (Fig. 2), SPPB (Fig. 3), and balance (Fig. 4) performance are presented in Figs. 2, 3, and 4.

Participants on a diet and exercise intervention walked an average of 0.13 m/s faster than control participants (95 % CI 0.06 to 0.21; I^2=0 %, 2 studies, 53 participants; Fig. 2). Gait speed is usually obtained by a test that requires the individual to walk a certain distance (e.g., 8 m) at a comfortable fast pace, to derive the gait speed in meters per second. According to previous literature, changes in gait speed over 0.1 m/s are clinically meaningful; specifically, a decrease in gait speed of 0.1 m/s has been associated with a 10 % decrease in the ability to perform instrumental activities of daily living [50]. It is worth noting that the effect was mainly due to the Villarreal et al. study [49], conducted in obese elderly. On the contrary, gait speed of participants in the diet alone intervention groups was not different than participants in the control group (MD=0.04 m/s; 95 % CI −0.00 to 0.09; I^2=0 %; 4 studies, 205 participants).

Participants in the combined exercise and diet interventions had performance measure of SPPB values an average of 0.49 units higher than the control participants (95 % CI 0.15 to 0.84; I^2= 49 %; 4 trials; 661 participants; Fig. 3). This gain fails to reach the suggested threshold of 1 point that indicates clinically meaningful changes [51]. No trials provided data to assess the effect of the diet alone intervention on SPPB.

Two RCT with 4-arm factorial designs [47, 49] provided data on the one leg balance stand for the comparisons of diet alone and diet plus exercise (Fig. 4). Neither diet alone intervention (MD=1.12; 95 % CI −2.79 to 5.04; I^2=0 %; 2 trials, 51 participants), nor combination of diet + exercise (MD=3.47; 95 % CI −6.72 to 13.67; I^2=92 %; 2 trials, 53

participants) showed a consistent effect on balance measures. The results are highly heterogeneous for the combined intervention comparison.

The studies contained data for tests measuring functional capacity that could not be analyzed. The study by Radavelli- Bagatini et al. [46] showed that older women in the higher dairy intake tertile had lower odds for a slow timed up and go (TUG) test. Also regarding the TUG test, the study by Rydwik et al. [47] showed that the benefits achieved by 3 months of physical training was not improved in the combined nutrition and training intervention group. The participants in the study by Neville et al. [45] did not significantly improve their lower extremity physical function measured with the chair stand test after 16 weeks adhering to a diet rich in fruit and vegetables. And the study by Rydwik et al. [47] showed an improvement in the results of the chair stand test following a 3-month training intervention combined with a diet intervention.

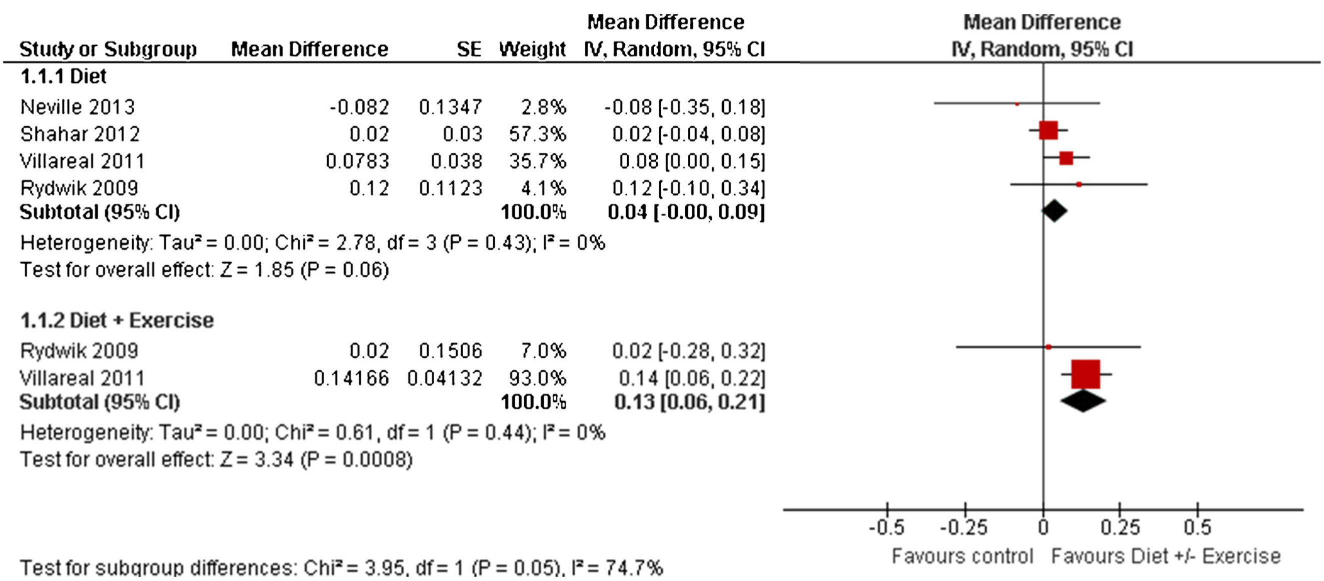

Fig. 2 Meta-analysis results of gait speed for diet and diet+exercise interventions

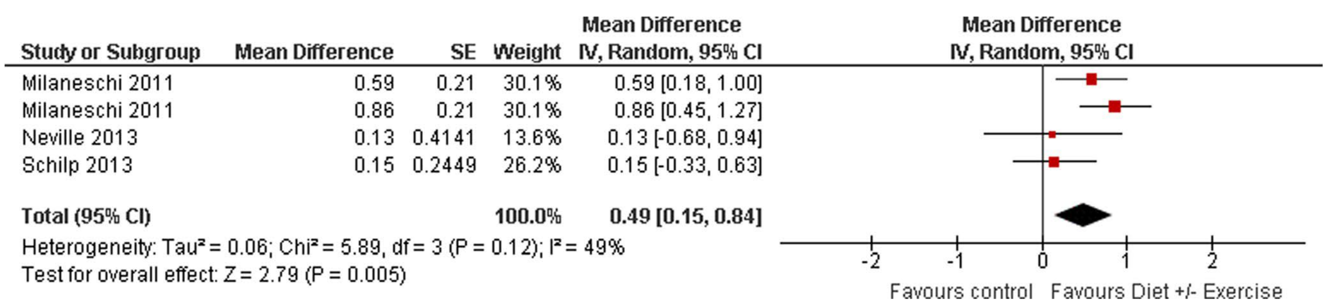

Fig. 3 Meta-analysis results of the short physical performance battery

Discussion

This systematic review has identified the available and recent evidence on the effect of exercise and diet interventions, and diet interventions alone to improve physical function in older adults. To our knowledge, this is the first systematic review focused on diet interventions to improve physical function in an elderly population older than 65 years of age. Combined exercise and diet interventions, when compared with control or diet interventions alone, improve walking speed and the SPPB in the community-dwelling older adults, although the SPPB results failed to show clinical significance. No consistent effect was observed for balance outcomes. Another major point to highlight is the paucity of data available in this population.

The strong points of this project are as follows: (1) its specific focus on a well-defined population (>65 years of age older adults; with and without non-communicable dis- eases, and community-dwelling (living in the community); (2) its inclusion of RCTs and observational studies; (3) the exclusion of diet supplementation interventions; and (4) the robust outcomes assessed (performance out- comes), which are relevant indicators of disability for rehabilitation and geriatric specialists. We have focused on older adults without dementia and dependency because this is a population in whom prevention of disability through physical activity is likely. For this reason, we have excluded hospitalized and institutionalized individuals, more likely to be dependent or in an unstable clinical condition, and in whom prevention of disability requires further attention.

Previous data show a beneficial effect of exercise for improving physical functioning in older adults, as measured by sit-to-stand performance, balance, agility, and gait speed [11–13, 14, 15, 16]. There is growing evidence that objective measures of physical performance such as grip strength, walking speed, chair rising, and standing balance not only characterize physical capability, but also act as a markers of current and future health [52]. Existing published reviews suggest that objective measures of physical capability may be useful predictors of subsequent health outcomes in community-dwelling populations [53, 54].

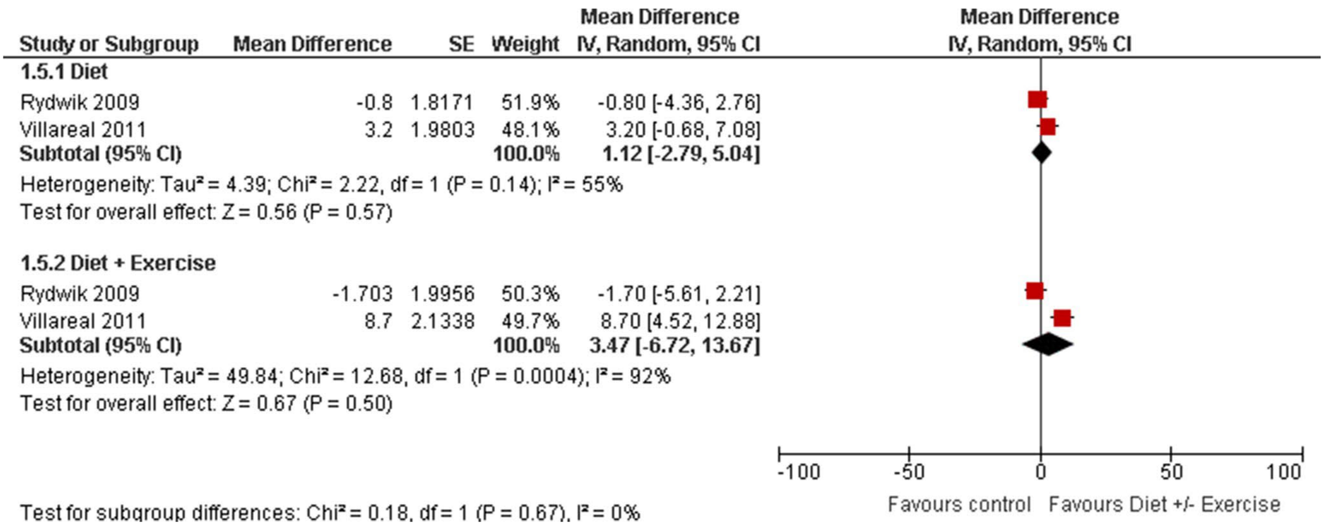

Fig. 4 Meta-analysis results of balance for diet and diet+exercise interventions

Unfortunately, there is a lack of available RCTs assessing diet interventions, and observational studies and RCTs assessing a combination of diet and exercises how highly heterogeneous diet interventions. Moreover, outcomes assessed within diet interventions are mostly different. Diet alone showed no improvements of physical function outcomes although some observational studies have found that individuals with "healthier" diets or with higher vegetables intake were more likely to have better functional health [55, 56]. Similarly, other intervention studies [57, 58] have suggested that a healthy diet, including increased fruit and vegetables intake, may enhance physical function, although these have largely focused on overall diet or lifestyle quality rather than intakes of specific food groups.

The assessment of dietary intake using different methods may have not accurately captured habitual dietary intake, particularly as it relies on memory recall, which for some older adults can pose a challenge. However, a recent systematic review which examined dietary assessment methods for micronutrient intake in elderly people, reported greater correlations with most micronutrients when a diet history was used to assess dietary intake, compared to a food frequency questionnaire [59].

The main question was whether diet combined with exercise could further improve exercise effects, according to standalone exercise-based recent systematic reviews. In one study [60], the authors concluded that the combination of a modest weight loss diet plus moderate exercise provided better overall improvements in self-reported measures of function and pain and in performance measures of mobility in older overweight and obese adults with knee osteoarthritis compared with either intervention alone, although the authors included a slightly younger population and with an specific chronic condition. In accordance, Rejeski et al. [61] concluded that a weight loss diet plus physical activity intervention further improved the 400-m walk test and achieved a higher loss of weight than the standalone physical activity intervention, in over- weight or obese older adults with cardiovascular disease. However, such improvement in mobility might not be clinically significant. Another study [62] found that a physical activity plus weight loss intervention program significantly improved function and decreased both fat and muscle cross-sectional area, compared to PA plus successful aging health education in overweight to moderately obese adults over the age of 60. Weight loss resulted in additional improvements in function over exercise alone, primarily due to loss of body fat. These results suggest that the loss of fat is important in improving function in generally healthy, overweight to moderately obese adults. Villareal et al.'s study [49] is in agreement with the findings of the aforementioned studies, which were not included in the present systematic review be- cause they all included a slightly younger population, concluding that a combination of weight loss and exercise provided greater improvement in physical function than either intervention alone. The present systematic review show further improvements with clinical significance in walking speed, although more information on what type of diet is most beneficial is required.

Finally, clinical practice guidelines include general recommendations of exercise in the elderly population [63]. On the contrary, no specific diet guidelines exist for this age group.

Conclusions

In conclusion, from these seven studies, combined exercise and diet interventions, when compared with control or diet interventions alone, have shown to improve walking speed and the SPPB in community-dwelling older adults, although the SPPB results failed to show clinical significance. No consistent effect was observed for balance outcomes. However, the evidence comparing different modalities of diet is scarce, and it is not possible to pinpoint which diet intervention is the most effective. Lifestyle-based data (diet and/or exercise) are scarce in this age group. In addition, although exercise intervention are known to improve physical function outcomes, based on current data, it is not possible to affirm that a combi- nation of diet and exercise interventions can further im- prove physical function. The findings of this review suggest that diet interventions and exercise intervention are highly heterogeneous, as well as outcome measures assessed.

Additional studies examining the impact of diet interventions and a combination of diet and exercise interventions to improve physical function outcomes are needed, especially in older people. This will help to develop more robust conclusions in the future and should encourage researchers to draw evidence-based specific diet guidelines for older adults.

Appendix 1

Databases	Search strategy
Medline (PubMed)	1. Aged [MeSH], elderly [MeSH], or older adults [tw]; elder [tw], aging [tw], or older people [tw]; or aging population [tw], retirement age [tw], or aged 65 and over [tw]
	2. Postural balance [MeSH], physical endurance [MeSH], muscle strength [MeSH], physical fitness [MeSH], functionality [tw], mobility[tw], aerobic capacity [tw], gait [tw], or strength[tw]
	3. Diet [MeSH], food intake [MeSH], food habits [MeSH], Mediterranean diet [MeSH], nutrient intake [tw], eating [MeSH], nutrition therapy [MeSH], dietary patterns [tw], dietary pattern [tw], eating pattern [tw], eating patterns [tw], food patterns [tw], food pattern [tw], dietary habits [MeSH], dietary [tw], dietary quality [tw], dietary diversity [tw], dietary variety [tw], dietary diversity score [tw], dietary quality index [tw], diet score [tw], diet index [tw], or diet therapy [MeSH]
	4. Exercise [MeSH], physical activity [MeSH], motor activity [MeSH], physical exercise [tw], or exercise therapy [MeSH]
	5. 1, 2, and (3 and 4)
	6. 1, 2, and 3

Table 2 Search strategy (before September 2014)

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