Preventive Medicine Reports 11 (2018) 231–239

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Review Article

Does modified Otago Exercise Program improves balance in older people? A systematic review

Anabela Correia Martins*, Cláudia Santos, Catarina Silva, Daniela Baltazar, Juliana Moreira, Nuno Tavares

IPC ESTeSC Coimbra Health School, Physiotherapy Department, Fall Sensing Project, Coimbra, Portugal

ARTICLE INFO

Keywords:
Otago Exercise Program
Community-dwelling older adults
Balance
Personalized exercise

ABSTRACT

Exercise interventions focused on strength and balance are effective for falls prevention in older people, however compliance to exercise is often a problem. Tailored intervention programs are recommended to meet the person preferences and increase compliance. Otago Exercise Program (OEP) is the most disseminated fall prevention program and is individually prescribed at home. The purpose of this study was to identify OEP modified formats and investigate their effects on balance when compared to its original form of delivering.

Four electronic databases were searched, PubMed, PEDro, Science Direct and Scopus, between January and February 2017. Eligibility criteria included experimental or qualitative design studies conducted among older adults (≥50 years) at risk of falling, ongoing exercise interventions with modified formats of OEP. The primary outcome was balance. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were used.

Eight studies met the inclusion criteria, five were randomized controlled trials (RCTs), two were quasi-experimental and one was a qualitative study. Therefore, a qualitative analysis was performed. Modified formats of OEP included additional vestibular or multisensory balance exercises, augmented reality, exercise in group and a DVD delivering format (in group or individual). In general, all studies using OEP modified formats reported improvements on balance and functional ability. However, it remains unclear if it is as effective as the original OEP and which modified format is more effective.

1. Introduction

Falls and fall-related injuries are a leading cause of morbidity and mortality among elderly, representing a serious public health problem (Dadgari et al., 2016; National Institute for Care Excellence, 2013; Otaka et al., 2017), and a significant threat to health, safety and independence (Chou et al., 2012). About one-third of people aged 65 years or more experience at least one fall annually (World Health Organization, 2007). Falls lead to social isolation, decrease of self-confidence and restriction on participation and activity limitations, promoting functional decline and dependence (Hartholt et al., 2011). Health care direct costs related to this phenomenon reaches 25 billion euros/year in the European Union (Carande-Kulis et al., 2015; Davis et al., 2010; ESA on Falls, 2015).

Current research demonstrates the effectiveness of exercise programs to reduce fall rate in community-dwelling older people, mainly strength and balance exercises for > 3 h/week (El-Khoury et al., 2013; Gillespie et al., 2012; Lacroix et al., 2016; Morris et al., 2016; Phelan et al., 2015; Sherrington et al., 2008, 2011, 2017). In fact, exercise as a single intervention can prevent falls in this specific population (Sherrington et al., 2017). Both individual and group exercise programs are equally effective (Gillespie et al., 2012; Sherrington et al., 2008, 2017), producing positive effects on mobility and physical functioning (de Vries et al., 2012). Additionally, preventive interventions comprising exercise with multiple components achieved a significant reduction in the rate and risk of falling (Gillespie et al., 2012).

The Otago Exercise Program (OEP) is the most widespread fall prevention program. It was developed at Otago Medical School and implemented across New Zealand by the Accident Compensation Corporation (Campbell and Robertson, 2003; Sherrington et al., 2011). The program includes strength and balance exercises, with a progression by increasing ankle cuff weights and number of sets, in association with a walking plan. It is recommended for community-dwelling older adults who can exercise safely on their own and who are able to

* Corresponding author at: ESTESC Coimbra Health School, Physiotherapy Department, Rua 5 de Outubro – S. Martinho do Bispo – Apartado 7006, 3040-162 Coimbra, Portugal.
E-mail address: anabelacmartins@estescoimbra.pt (A.C. Martins).

https://doi.org/10.1016/j.pmedr.2018.06.015
Received 14 February 2018; Received in revised form 21 June 2018; Accepted 24 June 2018
Available online 10 July 2018
2211-3355/ © 2018 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/BY-NC-ND/4.0/).

understand and follow the exercise instructions. Other inclusion criteria are history of falls, decrease in balance and strength, frailty or high risk of falling. The program is particularly effective in individuals with 80 years or older and is considered safe, effective, practical and a cost-effective approach for falls prevention (Campbell and Robertson, 2003; Robertson et al., 2002; Stevens and Burns, 2015).

The exercises are individually prescribed and delivered at participant's home, with four visits of the physiotherapist over the first two months, one visit at 6 and another at 12 months. Participants complete the exercises for 30 min/3 times a week and are encouraged to walk outside at least twice a week. To increase adherence and compliance, participants receive monthly phone calls between home visits (Campbell and Robertson, 2003; Sherrington et al., 2011; Stevens and Burns, 2015). The program is delivered for 12 months (Dadgari et al., 2016; Robertson et al., 2002; Stevens and Burns, 2015), but recently Shubert et al. (2017) described an innovative delivery model of 6 months.

Several studies, including systematic reviews with meta-analysis, recognize the OEP as an effective exercise prevention strategy with benefits in physical functioning and falls reduction (Dadgari et al., 2016; El-Khoury et al., 2013; Liu-Ambrose et al., 2008; Robertson et al., 2002; Sherrington et al., 2017; Shier et al., 2016; Thomas et al., 2010), even in elderly stroke patients (Park and Chang, 2016) and individual with age-related visual problems (Kovács et al., 2012). Other studies also recognize benefits, but the results are not conclusive (Binns and Taylor, 2011; Son et al., 2016).

Since falls are multifactorial, in addition to exercise, programs to prevent falls should address individual characteristics (National Institute for Care Excellence, 2013), such as health conditions, age, fear of falling, history of previous fall or self-efficacy for exercise (Picha and Howell, 2017). Moreover, they should be focused on the person needs, preferences and interests (Haas and Haines, 2014; Otaka et al., 2017; Shier et al., 2016). The increased need of tailored exercise programs resulted in the development of other exercise approaches, such as group exercise, technological support or health education. The combination of OEP with new approaches resulted in modified formats, however there are still few published studies (Benavent-Caballer et al., 2016). The main goals of this study were to identify other OEP delivering methods (modified formats) and analyze their effects on balance, functional ability and self-reported falls.

2. Methods

2.1. Study design

This systematic review was developed with reference to the "Preferred Reporting Items for Systematic Reviews and Meta-Analysis" (PRISMA) (Moher et al., 2015) and Cochrane Collaboration guidelines (Higgins and Green, 2011), for randomized trials.

2.2. Literature search strategy

2.2.1. Identification of studies

Literature search was performed by two authors, between January and February 2017 and four databases (PubMed, PEDro, Science Direct and Scopus) were searched. No limits related to language, publication date and length of follow-up were set.

Key search terms followed the PICO (participants, intervention, comparison, and outcome) elements strategy. Search term for population was "older adults", related terms were added as alternatives using "OR" ("Older adults" OR "elderly" OR "community-dwelling older adults"). Regarding intervention search term was "modified Otago". For comparison search term was "Otago Exercise Program". Finally, outcome measures search terms were "Fall prevention" and "balance". Search terms linked with "AND" were "older adults" AND "Otago Exercise Program"; "older adults" AND "modified Otago"; "older adults" AND "balance" AND "fall prevention"; "older adults" AND "Otago Exercise Program" AND "fall prevention".

To supplement the data provided, regarding exercise interventions based on OEP, websites and relevant protocol papers referenced in the original publications were also searched.

Eligibility criteria included full-text RCTs and other experimental designs and qualitative studies, conducted among community dwelling adults, with non-syncopal falls during the previous 12 months and/or functional ability indicating risk of falling (balance, strength and gait tests), whose main exercise intervention strategy was a OEP modified format. The studies must include a comparison with a control group performing the original OEP or, alternatively, a non-intervention or a different type of exercise group. The primary outcome was balance measured by Berg Balance Scale (BBS), One-leg Stand Test (OLS), Functional Reach Test (FRT), Step Test, Functional Gait Assessment (FGA), Timed Up and Go Test (TUG) and 30-seconds Sit-to-Stand. However, other outcome measures were considered for secondary analysis and discussion (compliance to exercise and program, self-reported falls, participant attitudes, exercise facilitators and difficulties).

2.2.2. Study selection

Studies were scanned for inclusion based on title. The abstracts were only reviewed if their title identified all elements of PICO. If an abstract had insufficient information to allow its inclusion, full-text reading was performed. Any disagreement was resolved by consensus.

2.2.3. Quality assessment of studies

The quality of the RCTs was assessed through PEDro scale, consisting of 11 items based on a Delphi list (Verhagen et al., 1998).

The 11 items included Eligibility criteria (1); Random allocation (2); Concealed allocation (3); Baseline comparability (4); Blind subjects (5); Blind therapists (6); Blind assessors (7); Adequate follow-up (8); Intention-to-treat analysis (9); Between-group comparisons (10); Point estimates and variability (11). The item eligibility criteria do not contribute to total score, since it is related to external validity (Maher et al., 2003).

2.2.4. Studies analysis

All the included studies were described in terms of study design, sample size, length of follow-up, sample characteristics, intervention components, outcomes related with balance and compliance to the program. PEDro scale was used to assess quality of RCTs.

It was not possible to perform a full meta-analysis because few studies were identified and there was methodological variability in the definition of the outcome to measure balance/postural stability.

Therefore, a simple qualitative analysis (narrative synthesis of the data) was conducted for the included studies.

3. Results

3.1. Overview of studies identified

1249 studies were identified through database and hand searching. After duplicates removal, the search was reduced to 1209 studies of potential interest for title/abstract examination. After a critical review of the fifteen full-text studies selected, eight met the inclusion criteria (Fig. 1).

Concerning study design, five relevant and recent articles were RCTs (Benavent-Caballer et al., 2016; Kyrdalen et al., 2014; Liston et al., 2014; Yang et al., 2012; Yoo et al., 2013), two were quasi-experimental (Davis et al., 2016; Waters et al., 2011) and one was a qualitative study carried out from a subsample of another experimental study (Agha et al., 2015).

Table 1 summarizes the characteristics of the included studies, concerning study design, participants, intervention, comparison, outcomes, follow-up and adherence.

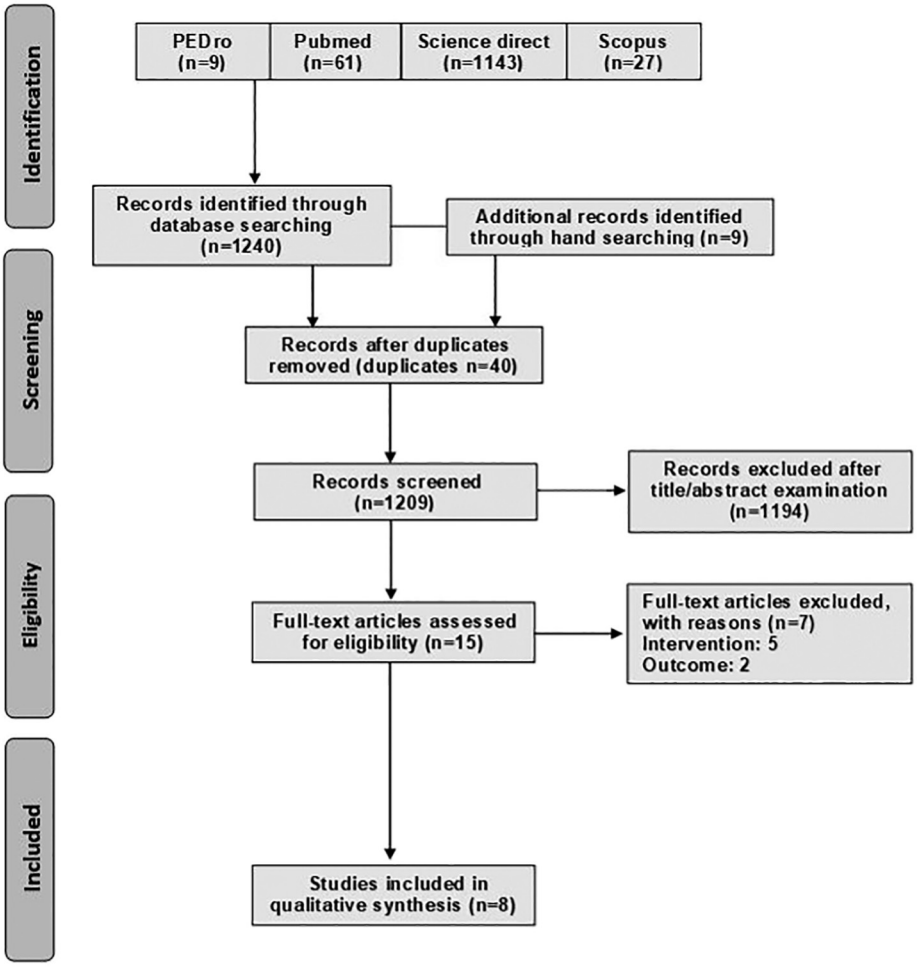

Fig. 1. Flow diagram for studies inclusion.

3.2. Studies quality

On the quality assessment with PEDro scale two RCTs obtained a score of 5 (Liston et al., 2014; Yoo et al., 2013), one a score of 6 (Kyrdalen et al., 2014) and two a score of 7 (Yang et al., 2012; Benavent-Caballer et al., 2016) (Table 2). According to these scores, low/moderate quality of the studies is related with withdrawals during follow-up (criterion 8 of the scale), concealed allocation and blind assessment not clearly exposed by the authors (criterion 3 and 6 of the scale) and one study did not provide measures of variability for some key outcomes (criterion 11 of the scale). All RCTs had similar groups at baseline, although the sample size and the length of follow-up varied between studies. Sample size ranged from 21 (Liston et al., 2014; Yoo et al., 2013) to 165 (Yang et al., 2012) and the length of follow-up varied between 2 (Liston et al., 2014) and 6 months (Yang et al., 2012). In the quasi-experimental study conducted by Waters et al. (2011) the follow-up was extended to 12 months.

3.3. Studies results

3.3.1. Modified formats of OEP

All the seven experimental studies tested different modified OEP formats. Those formats involved additional vestibular exercises (Yang et al., 2012), augmented reality (Yoo et al., 2013), exercise in group (classes) with physiotherapists (Kyrdalen et al., 2014), peer-led (Waters et al., 2011) or supplemented with multisensory balance exercises at home (Liston et al., 2014). The program was also delivered in a DVD format both to community centre (group classes) and (Benavent-Caballer et al., 2016) to a rural community (individual use at home) (Agha et al., 2015; Davis et al., 2016).

The included studies involved a total of 604 community-dwelling adults, both men and women, with a mean age of 76.75 years (SD = 5.5), except for Yoo et al. (2013) women-only study.

All RCTs had one intervention group and one control group, except Waters et al. (2011), quasi-experimental study, that included two exercise intervention groups and one control group. Qualitative study from Agha et al. (2015) described an 6 months OEP-DVD intervention.

3.3.2. Balance and functional ability

In general, the five RCTs and the two quasi-experimental studies reported improvements in balance and general mobility outcomes with OEP modified formats.

Benavent-Caballer et al. (2016) reported that a video-supported group-based OEP may significantly improve levels of mobility, functional balance, one-leg balance and lower extremity strength when compared to a control group (CG) (no intervention). After 4 months, the TUG scores significantly decreased in the intervention group (IG) [IG 7.5 (2.0) vs CG 8.8 (1.9), mean difference −1.3 s, 95% confidence interval (CI) of the difference −2.3 to −0.1; $p = 0.03$]. A significant improvement was also recorded in functional balance (BBS) [IG 54.9 (2.5) vs CG 51.4 (5.3), mean difference 3.5 points, 95% CI 1.2 to 5.8; $p = 0{,}003$], one leg balance (OLS) [IG 39.1 (21.6) vs CG 15.6 (12.1), mean difference 23.5 s, 95%CI 13.3 to 33.7; $p < 0.001$] and lower extremity strength [IG 8.7 (3.8) vs CG 10.9 (3.3), mean difference −2.2 s, 95%CI −4.2 to −0.1; $p = 0.035$] in the intervention group compared to the control group.

Table 1
Studies characteristics.

Study	Study design	Participants	Intervention	Comparison	Outcome measures	Follow-up	Dropouts
Benavent-Caballer et al. (2016)	RCT	N = 51; age ≥ 65 years; Community-dwelling older people; ambulate independently without walking aid; no contraindication for physical activity; able to communicate; and have self-reported visual and auditory capacities to follow the exercises. Risk of falling assessment: age and functional ability. Intervention group (IG): N = 28; Women = 82% Age (years) = 69,1 (SD = 4) Control group (CG): N = 23; Women = 69% Age (years) = 69 (SD = 3,3)	IG: Otago Exercise Program (OEP) delivered by DVD in a community centre. 3 Initial sessions supervised by a physiotherapist, with weekly visits to the community centre. Individuals followed exercise instructions. Each session included warm-up, strength and balance exercises, walking and a cool-down period. It was suggested to incorporate walking times during daily activities. Frequency: 3 times/week Duration: 45 min/session Format: group exercise	CG: no intervention Maintained daily routine	Primary: TUG Secondary: BBS 6 MWT OLS SPPB	4 months (assessments at 0 and 4 months)	Dropout (IG): 15% after 1st month; 30% at the end of intervention (4th month)
Kyrdalen et al. (2014)	RCT	N = 125; mean age (years) = 82,5 (SD = 5,6); Risk of falling assessment: Older people referred to a Falls Outpatient Clinic with high risk of falling (73% had fallen; 36% had a fall-related hospital stay; 58% lived alone) Intervention group (IG): N = 62; Women = 69,4% Age (years) = 82,9 (SD = 5) Concomitant diseases = 3 (SD = 1,3) Prescribed medications = 5,5 (SD = 2,7) Control group (CG): N = 63; Women = 76,2% Age (years) = 82,1 (SD = 6,4) Concomitant diseases = 2,9 (SD = 1,6) Prescribed medications = 6,2 (SD = 2,8)	IG: OEP protocol in classes – group training (4–8 individuals in each class) Supervised by physiotherapists; Individualized load and progression. Frequency: 2 times/week Duration: 45 min/session Format: group exercise	CG: Original OEP at home Physiotherapist visits: weeks 1, 2, 4 and 8. Visit duration: 1 h. Participants received a phone call once a month between home visits. Frequency: 3 times/week Duration: 30 min/session Format: individual exercise	Primary: TUG Secondary: BBS 30 STS 7 Item FES SF-36 Number of falls (T2)	T1 – baseline T2–12 weeks T3–3 months after the end of intervention	Dropout (IG): T2–24% T3–35% Dropout (CG): T2–25% T3–32%
			Both groups were encouraged to walk 3 or more times/week for 30 min and to continue the OEP after the end of intervention.				
Liston et al. (2014)	RCT	N = 21; age ≥ 65 years; community-dwelling older people with ≥ 2 falls during previous 12 months; no vestibular dysfunction. Risk of falling assessment: age and fall history in the previous 12 months Intervention group (IG): N = 10; Women = 80% Age (years) = 77,8 (69–87) Control group (CG): N = 11; Women = 82% Age (years) = 76,7 (69–86)	IG: Modified OEP in group class supplemented with supervised home-based multisensory balance exercises (4/5 exercises)	CG: Modified OEP in group class supplemented with supervised home-based stretching exercises (4/5 exercises)	Primary: FGA Secondary: Number of falls at 6 months	2 months Telephone follow-up at 6 months	Dropout (IG): 2 months – 30% Dropout (CG): 2 months – 27,3%
			Modified OEP in group class included warm-up, strength and balance exercises based on the original OEP. Assessments at baseline, 4 and 8 weeks. Delivery of a worksheet with diagrams and written explanations of exercises (depending on group) to be independently practiced twice a day (with exception of the days with supervised home sessions) Frequency: 2 times/week (group exercise class + supervised home sessions) Duration: 1 h exercise class + 45 min supervised home exercise Format: group exercise + individual exercise at home				
Yoo et al. (2013)	RCT	N = 21; community-dwelling older women with sufficient cognitive ability to participate; without disabilities in visual, auditory sensation and vestibular organs, or fractures in the past year. Risk of falling assessment: age and	IG: augmented reality-based Otago exercise Subjects stood in front of a computer with a web camera, which had an SVGA resolution head-mounted display and followed the movement displayed. The computer sensed the	CG: OEP at home	Primary: BBS Secondary: Gait Function (GAITRite system) FES-I	3 months	No dropouts

(*continued on next page*)

Table 1 (*continued*)

Study	Study design	Participants	Intervention	Comparison	Outcome measures	Follow-up	Dropouts
		functional ability Intervention group (IG): N = 10 Age (years) = 72,9 (SD = 3,41) Control group (CG): N = 11 Age (years) = 75,64 (SD = 5,57)	movement and sent the information to the screen in order to repeat the task and move to the next level. Each session included warm-up, strength and balance exercises (40 min) and a cool-down period (10 min). Frequency: 3 times/week Duration: 60 min/session Format: individual exercise				
Yang et al. (2012)	RCT	N = 165; age ≥ 65 years; community-dwelling older people with concerns about balance; ambulate independently; ≤1 fall in the previous 12 months; mild balance dysfunction (identified after previous assessment). Risk of falling assessment: age, falls history and functional ability Intervention group (IG): N = 82; Women = 45,1% Age (years) = 81 (SD = 5,9) Control group (CG): N = 83; Women = 43,4% Age (years) = 80,1 (SD = 6,4)			IG: personalized home exercise program prescribed by a PT based on the OEP and the Visual Health Information Balance and Vestibular Exercise Kit – mostly 5 to 8 exercises. The program consisted of general warm-up, balance and strength exercises, and a tailored walking program. Home visits by the same physiotherapist on weeks 1, 4 and 8 for progressive adjustments, monitoring and support exercise adherence. Frequency: 2 times/week Duration: 50 min/session (20 min prescribed exercises + 30 min walking) Format: individual exercise Individuals were encouraged to perform exercises 5 times per week	CG: no intervention Usual activity	Primary: Clinical and laboratory measures of balance performance (FRT, Step Test, Five-Time Sit-to-Stand, lower-limb muscle strength, walking speed, and others) Secondary: Measures of strength and mobility, activity level, health-related quality of life, fear of falling and number of falls at the end (6 months)
6 months	Dropout at 6 months: IG – 28% CG – 25,3%						
Davis et al. (2016)	Pre-post intervention (non-randomization)	N = 82; age ≥ 75 years; community-dwelling older people able to walk 100 m independently (with or without assistive device); MMSE score > 24 Risk of falling assessment: age and functional ability Intervention group (IG): N = 61; Women = 65,6% Mean age (years) = 79,5 (SD = 4,8) Control group (CG): N = 21; Women = 76,2% Mean age (years) = 79,9 (SD = 5)	IG: Otago Exercise Program delivered by an interactive DVD (OEP-DVD) in a rural community. One home visit by a physiotherapist at the beginning. Monthly phone calls to discuss progress, concerns and answer questions. Each phone session was scheduled for 15 min. Frequency: 3 times/week Duration: 30 min/session Format: Individual exercise	CG: no intervention Individuals from an urban community completed monthly falls calendars. After 6 months, all individuals in the control group were also given the OEP-DVD and one home visit by a physiotherapist	Primary: Feasibility (withdrawal rate) SPPB PPA ABC	6 months	Dropout (IG): 6 months – 28%
Agha et al. (2015)	Qualitative	N = 21; aged from 74 to 97 years; rural community-dwelling older people Risk of falling assessment: age and functional ability Mean age (years) = 81,48; Women = 78,9% Group interview – N = 5 Individual interview – N = 16	Group and individual interviews in subjects who participated in a 6 months OEP-DVD intervention. For individual interview participants could choose between face to face or telephone interview	–	Understanding of participants' experience with the OEP-DVD	–	–

(*continued on next page*)

Table 1 (*continued*)

Study	Study design	Participants	Intervention	Comparison	Outcome measures	Follow-up	Dropouts
Waters et al. (2011)	Quasi-experimental	N = 118; age ≥ 65 years (≥ 55 years for indigenous people of New Zealand); Individuals with increased fall risk. Risk of falling assessment: age, fall history in the previous 12 months; functional ability Group 1: N = 52; Women = 83% Mean age (years) = 76,5 (SD = 7,4) Group 2: N = 41; Women = 76% Mean age (years) = 77 (SD = 6,6) Group 3: N = 25; Women = 68% Mean age (years) = 78,4 (SD = 7,5)	Exercise classes based on OEP Group 1 – peer-led group (Strength and balance exercise classes adapted from OEP delivered in a standardized and progressive manner by the peer) Group 2 – age Concern Otago (Strength and balance exercise classes adapted from OEP delivered in a standardized and progressive manner by a professional instructor) Frequency: 1 session/week Duration: 60 min/session Format: exercise in group (class)	CG: Group 3 - seated exercise classes taught by a trained instructor who followed a standardized, progressive exercise program from a manual and DVD (seated flexibility, range of motion, and seated aerobic exercises)	Primary: TUG 30 STS FRT ST SLS ABC Falls rate at 12 months	T1 - baseline T2–10 weeks intervention T3–6 months T4–12 months	Dropout at 12 months: 23%

FGA – Functional Gait Assessment; FRT – Functional Reach Test; SPPB – Short Performance Physical Battery; PPA – Physiological Profile Assessment; ABC – Activities-Specific Balance Confidence Scale.

Table 2
Study quality on PEDro scale.

	Study	1[a]	2	3	4	5	6	7	8	9	10	11	Total
1	Benavent-Caballer et al. (2016)	x	x	x	x			x		x	x	x	7/10
2	Kyrdalen et al. (2014)	x	x		x			x		x	x	x	6/10
3	Liston et al. (2014)	x	x		x			x			x	x	5/10
4	Yoo et al. (2013)		x		x				x		x	x	5/10
5	Yang et al. (2012)	x	x	x	x			x		x	x	x	7/10

1: Eligibility criteria, 2: Random allocation; 3: Concealed allocation; 4: Baseline comparability; 5: Blind subjects; 6: Blind therapists; 7: Blind assessors; 8: Adequate follow-up; 9: Intention-to-treat analysis; 10: Between-group comparisons; 11: Point estimates and variability.

[a] Eligibility criteria item does not contribute to total score.

Liston et al. (2014) analysed the contribution of multisensory balance exercises compared to stretching exercises in association with group-based OEP, during 2 months. The authors stated that multisensory exercises can feasibly and safely be added to this modified OEP in older people. In fact, FGA showed significant improvements ($p < 0.01$, $r = -0.71$), revealing that OEP + multisensory exercises group may be beneficial on fall risk.

Kyrdalen et al. (2014) also used a modified version of OEP performed as group training compared to original OEP performed at home. At baseline, 74% of the individuals had fallen and 37% had a fall-related hospital stay during the previous year. According to the results, the modified OEP was more effective improving functional balance, muscle strength and physical health. After 12 weeks of intervention (T2), BBS (mean difference 3.2 points, 95%CI = 0.7–5.8, $p = 0.014$) and 30-seconds Sit-to-Stand test (mean difference 2.2, 95%CI = 0.7–3.6, $p = 0.004$) significantly improved in the intervention group. However, TUG did not differ between groups after the intervention (mean difference −2.1 s, 95%CI = −4.3–0.1, $p = 0.059$). Three months after the end of the intervention (T3) the intervention group demonstrated more sustained effects concerning these outcomes.

Considering individual and personalized OEP interventions, two other RCTs focused on different approaches. Yang et al. (2012) verified that a personalized home-based exercise program, prescribed by a physiotherapist, based on the OEP and on the Visual Health Information Balance and Vestibular Exercise Kit, improved balance, strength and function. Moreover, it may improve mild balance dysfunction in older people. Regarding balance, after six months, the intervention group significantly improved the FRT (mean difference 2.95 cm, 95%CI 1.75 to 4.15; $p < 0.001$) and the Step Test (mean difference 2.10 steps/15 s, 95%CI 1.17 to 3.02; $p < 0.001$), when compared with a non-intervention group. Significant improvements were also observed on hip abductor strength and gait step ($p < 0.001$). Yoo et al. (2013) analysed the effect of augmented reality-based OEP on balance, gait, and falls efficacy of elderly women, compared with original OEP. After intervention, augmented reality-based OEP revealed significant improvements in balance (BBS, $p < 0.001$), gait parameters (velocity, $p < 0.01$; cadence, $p < 0.001$) and falls efficacy ($p < 0.05$).

Davis et al. (2016) considered an alternative method of delivering individual OEP via an interactive DVD (OEP-DVD) in older adults living in a rural community, with a single visit from a physiotherapist in combination with monthly phone calls. After 6 months of intervention, the OEP-DVD significantly reduced fall risk, when compared to control group (subjects had no intervention) ($p = 0.007$). In addition to fall risk reduction, the authors of this quasi-experimental study with non-randomization, emphasize the importance of these results on public health in reaching rural populations. In another non-randomized study, Waters et al. (2011) evaluated strength, balance and falls incidence in older adults who performed fall prevention exercise classes based on strength and balance exercises adapted from OEP, taught by volunteer peer leaders (Group 1), paid professional (Age Concern Otago group - Group

2), and a comparison group (CG with standardized seated exercises - Group 3). Functional measures (TUG, 30 STS, OLS, FRT, Step Test) significantly improved, after 10 weeks of intervention and at 1-year follow-up, in both intervention groups, when compared to control group ($p = 0.02$).

Agha et al. (2015), in a qualitative study, aimed to understand older adults' experiences using DVD-delivered OEP and to explore barriers and facilitators to implementing this modified OEP from the participants' perspective. Thirty-two older adults met the eligibility criteria, 5 participated in group interviews and 16 in individual interviews. Most participants found the DVD-delivered OEP a useful training tool and appreciated the flexibility of the program. They considered it positively impacted their physical and mental health by improving their balance and lower body strength, and consequently reduced their fear of falling. Although they mentioned possible barriers for engaging certain domestic activities and exercise, such as living with chronic health conditions and living very busy lives, most participants intended to continue the OEP. In a social context, some participants described lack of social contact and that the program as becoming boring and repetitive as they became familiar with exercises. Some suggested adding a group exercise option to the home-based program, however others preferred to exercise alone and with minimal instructions. All participants considered the guidance and motivation given by the physiotherapist beneficial.

3.3.3. Self-reported falls

Four studies assessed fall history in the previous 12 months and the number of falls occurred during intervention programs and/or at the end of follow-up. These data were mainly used as descriptive information or a secondary outcome.

In Yang et al. (2012) trial, 20% of the participants in the IG (12 out of 59) and 29% in the CG (18 out of 62) fell during the 6-months intervention period. In addition, the IG registered less multiple fallers (2 out of 59) than the CG (8 out of 62). Despite these differences the results were not statistically significant.

Kyrdalen et al. (2014), reported falls occurrence during the 3-months intervention, 31% for the IG (group training) and 27% for the CG (home training). After 3-months follow-up, 29% from the group training and 22% from the home training reported a fall.

Liston et al. (2014) reported that 3 individuals fell in both IG (multisensory rehabilitation group) and CG (stretching exercise group), during the 2-months intervention period. Six months after intervention, one individual in the IG reported two falls and two individuals in the CG reported two and three falls, respectively.

After a 12-month period, Waters et al. (2011) recorded a total of 123 reported falls in their study, 84 did not result in injuries, with no significant differences between the two interventional groups and the control group. Nevertheless, the results showed a tendency for a 27% decrease in falls in the peer-led group (Group 1) and no tendency for decrease in the Age Concern Otago group (Group 2), compared to control group.

3.3.4. Compliance to program and exercise during intervention

With the exception of Yoo et al. (2013), which did not register any dropout, withdrawal rate ranged between 23% (Waters et al., 2011) and 30% (Benavent-Caballer et al., 2016; Liston et al., 2014) (Table 1).

Compliance to exercise was not assessed in all studies. In one study (OEP-DVD in group) (Benavent-Caballer et al., 2016) the intervention group attended 77% of the planned sessions. Yang et al. (2012) verified that, of the 59 individuals who completed the intervention, 44,1% performed the exercise program 5 or more times per week, 39% exercised 3 or 4 times, and 13,6% exercised less than twice a week. Davis et al. (2016) observed that of the 44 individuals who completed the intervention, 16 demonstrated 100% compliance performing the OEP-DVD exercises at least twice a week, 33 demonstrated 100% walking compliance and 30 showed 100% overall compliance (OEP-DVD + walking). During a 12-weeks intervention, other researchers (Kyrdalen et al., 2014) noticed that the mean number of exercise sessions attended by the IG (OEP in group) was 21.9 (SD = 2.7) (total of 24 sessions) and by the CG (OEP at home) was 32.8 (SD = 2.8) (total of 36 recommended sessions).

3.3.5. Exercise maintenance after intervention

Concerning exercise maintenance, two studies analysed compliance to exercise after intervention (Kyrdalen et al., 2014; Waters et al., 2011). One trial investigated compliance to exercise between the end of intervention (T2) and three months later (T3) (Kyrdalen et al., 2014). It was found that 19 individuals in IG (n = 40) and 14 in CG (n = 43) continued to perform the home exercise program at least twice a week. In other study, at 6 months' post-intervention 84,7% of the participants reported to perform the once-weekly strength and balance exercise classes and at 12-months this percentage decreased slightly to 79,1% (Waters et al., 2011). Exercise maintenance after intervention was higher in the intervention groups (OEP exercise classes) when compared to control group.

4. Discussion

This review primarily aimed to identify modified formats of delivering OEP and study their effects on balance and fall prevention. Recent systematic reviews and meta-analysis have investigated the effects of different exercise programs (including OEP) to prevent falls, but not OEP modified formats (Gillespie et al., 2012; Sherrington et al., 2008, 2011, 2017; Shier et al., 2016; Thomas et al., 2010).

Nevertheless, the few studies and the methodological differences, all OEP modified formats showed improvements on balance and other physical functioning related outcomes. They all provide insights on how other components and/or strategies added to the original OEP may act in falls occurrence.

Some studies had no intervention in the control group which did not allow the comparison between modified and original OEP interventions. Besides, it is expected physical benefits with exercise interventions when compared with no intervention.

Despite the constraints mentioned, the results suggest that modified OEP can be beneficial for physical functioning improvement (especially on balance outcomes) if delivered by video/DVD (individual at home or in group), as exercise group classes, as OEP with supplementary multisensory balance exercises and as augmented reality-based Otago. When applied in different contexts, modified OEP also showed a good acceptance, met the participants' expectations and improved social participation (group interventions).

There are benefits in the use of OEP modified formats. For instance, direct visual feedback can be provided with an augmented reality-based OEP environment (Yoo et al., 2013). Other authors suggest that exercise programs can be delivered in group or individually home-based considering individual preferences (Sherrington et al., 2011; Shier et al., 2016). This review found that both home-based and group-based OEP can be successfully implemented, even if supported by DVD/Video. The importance of OEP in group is recognized, since exercising in class can bring additional psychological and social benefits to a falls prevention program. For some authors, OEP in group is consistent with best-practice in public health, because it is more effective for empowering people to promote their health, decrease costs and achieve long-standing exercise adherence compared with an individual approach (Waters et al., 2011). Agha et al. (2015) reinforced that implementing OEP in group allows reaching to older people living in outlying geographical areas, and may be useful for participants to perform OEP with family members or peers.

Additional home-based exercises supplementing OEP group sessions are a strategy that can be effective (Liston et al., 2014). Multisensory balance exercises in combination with OEP were used to add some components that are not considered in OEP exercises and may be

implicated in the cause of falls (e.g. anticipatory postural adjustments). Multisensory balance exercises combined with OEP (32 h/8 weeks) had positive effects on balance and fall risk. According to the current evidence (Sherrington et al., 2017), exercises that challenge balance, and use a higher total dose of exercise (3 h/week minimum) are recommended to improve the effectiveness of falls prevention programs.

This study showed that, even within the OEP modified formats, compliance to exercise is a concern, with the number of dropouts reaching 30%. After 2 months of intervention, improvements were achieved in balance. However, the neurophysiological adaptations gained with exercise can only be maintained in long term sustained exercise programs. On a previous review, Thomas et al. (2010) concluded that the higher levels of compliance the greater benefits of OEP. At 12-months, they verified that 55,9% of the participants (total of 747) were still performing the OEP two times a week and 36,7% three times a week. At 6-months' reassessment, Yang et al. (2012) had similar results of compliance. Additionally, motivational factors also influence compliance to exercise (Arkkukangas et al., 2015; McMahon et al., 2016; Sherrington et al., 2017).

Current investigation in falls prevention has been testing new technologies for fall risk assessment and assistive personalized exercise interventions (mainly strength and balance exercises), involving interactive Video/DVD, videogames or exergames with feedback of movement performance at home and community environments (Gschwind et al., 2015; Hamm et al., 2016; Kwok and Pua, 2016; Schoene et al., 2013; Schwenk et al., 2014; van Diest et al., 2016). This review confirmed that older people at risk of falling can benefit from technology-based interventions to improve physical functioning and it may be a solution for increasing compliance to exercise.

Besides physical functioning, the decision about which program to offer may depend on many features (facilitators or barriers), such as, geography (e.g. urban versus rural), individual preferences, self-efficacy for exercise, technological literacy, available resources, patients' needs for tailored exercises, and the need for more supervision and/or socialization. According to literature, the compliance and success of an exercise program mainly depends on the program characteristics and personal factors, such as the level of general self-efficacy (Picha and Howell, 2017; Picorelli et al., 2014).

OEP modified formats (more or less technology-based) may be valuable resources if they contribute to a more interactive, feasible and personalized fall prevention program.

5. Conclusion

The findings of this review suggests that modified formats of OEP improve physical function (particularly, balance). Considering the limitations, it remains unclear if it is as effective as the original OEP and which modified format is more effective. However, it is highly important the prescription of tailored interventions for falls prevention, considering a biopsychosocial approach.

Conflict of interest

The authors declare that there are no conflicts of interest.

Funding

Financial support from project FallSensing: Technological solution for fall risk screening and falls prevention, co-funded by Portugal 2020, framed under the COMPETE 2020 (Operational Programme Competitiveness and Internationalization) and European Regional Development Fund (ERDF) from European Union (EU). Funder approval number: POCI-01-0247-FEDER-003464.

Authors' contributions

ACM, CS and DB contributed to the design of this systematic review; CS and DB contributed to literature searching, eligible study identification, data extraction, data analysis and manuscript drafting; CS, DB, CatS, JM and NT contributed to the manuscript editing and ACM, CatS and JM reviewed the final version.

References

Agha, A., Liu-Ambrose, T.Y.L., Backman, C.L., Leese, J., Li, L.C., 2015. Understanding the experiences of rural community-dwelling older adults in using a new DVD-delivered Otago Exercise Program: a qualitative study. Interact. J. Med. Res. 4, e17. https://doi.org/10.2196/ijmr.4257.

Arkkukangas, M., Johnson, S.T., Hellström, K., Söderlund, A., Eriksson, S., Johansson, A.C., 2015. A feasibility study of a randomised controlled trial comparing fall prevention using exercise with or without the support of motivational interviewing. Prev. Med. Rep. 2, 134–140. https://doi.org/10.1016/j.pmedr.2015.01.007.

Benavent-Caballer, V., Rosado-Calatayud, P., Segura-Ortí, E., Amer-Cuenca, J.J., Lisón, J.F., 2016. The effectiveness of a video-supported group-based Otago Exercise Programme on physical performance in community-dwelling older adults: a preliminary study. Physiotherapy 102, 280–286. https://doi.org/10.1016/j.physio.2015.08.002.

Binns, E., Taylor, D., 2011. The effect of the Otago Exercise Programme on strength and balance in community dwelling older women. N. Z. J. Physiother. 39, 63–68.

Campbell, A., Robertson, M., 2003. Otago Excercise Programme to Prevent Falls in Older Adults. Accident Compensation Corporation (ACC), University of Otago, New Zeland.

Carande-Kulis, V., Stevens, J.A., Florence, C.S., Beattie, B.L., Arias, I., 2015. A cost-benefit analysis of three older adult fall prevention interventions. J. Saf. Res. 52, 65–70. https://doi.org/10.1016/j.jsr.2014.12.007.

Chou, C.-H., Hwang, C.-L., Wu, Y.-T., 2012. Effect of exercise on physical function, daily living activities, and quality of life in the frail older adults: a meta-analysis. Arch. Phys. Med. Rehabil. 93, 237–244. https://doi.org/10.1016/j.apmr.2011.08.042.

Dadgari, A., Aizan Hamid, T., Hakim, M.N., et al., 2016. Randomized control trials on Otago Exercise Program (OEP) to reduce falls among elderly community dwellers in Shahroud, Iran. Iran Red Crescent Med J 18, e26340. https://doi.org/10.5812/ircmj.26340.

Davis, J.C., Robertson, M.C., Ashe, M.C., Liu-Ambrose, T., Khan, K.M., Marra, C.A., 2010. Does a home-based strength and balance programme in people aged ≥80 years provide the best value for money to prevent falls? A systematic review of economic evaluations of falls prevention interventions. Br. J. Sports Med. 44, 80–89. https://doi.org/10.1136/bjsm.2008.060988.

Davis, J.C., Hsu, C.L., Cheung, W., et al., 2016. Can the Otago falls prevention program be delivered by video? A feasibility study. BMJ Open Sport Exerc. Med. 2, e000059. https://doi.org/10.1136/bmjsem-2015-000059.

van Diest, M., Stegenga, J., Wörtche, H.J., Verkerke, G.J., Postema, K., Lamoth, C.J.C., 2016. Exergames for unsupervised balance training at home: a pilot study in healthy older adults. Gait Posture 44, 161–167. https://doi.org/10.1016/j.gaitpost.2015.11.019.

El-Khoury, F., Cassou, B., Charles, M.A., Dargent-Molina, P., 2013. The effect of fall prevention exercise programmes on fall induced injuries in community dwelling older adults: systematic review and meta-analysis of randomised controlled trials. BMJ 347, 1–13. https://doi.org/10.1136/bmj.f6234.

ESA on Falls, 2015. Active ageing through preventing falls: “falls prevention is everyone's business” ([WWW Document]. URL). https://eupha.org/repository/sections/ipsp/Joint_Declaration_Sept_2015.pdf, Accessed date: 30 January 2018.

Gillespie, L.D., Robertson, M.C., Gillespie, W.J., et al., 2012. Interventions for preventing falls in older people living in the community. Cochrane Database Syst. Rev. 9. https://doi.org/10.1002/14651858.CD007146.pub3.

Gschwind, Y.J., Eichberg, S., Ejupi, A., et al., 2015. ICT-based system to predict and prevent falls (iStoppFalls): results from an international multicenter randomized controlled trial. Eur. Rev. Aging Phys. Act. 12, 1–11. https://doi.org/10.1186/s11556-015-0155-6.

Haas, R., Haines, T.P., 2014. Twelve month follow up of a falls prevention program in older adults from diverse populations in Australia: a qualitative study. Arch. Gerontol. Geriatr. 58, 283–292. https://doi.org/10.1016/j.archger.2013.10.010.

Hamm, J., Money, A.G., Atwal, A., Paraskevopoulos, I., 2016. Fall prevention intervention technologies: a conceptual framework and survey of the state of the art. J. Biomed. Inform. 59, 319–345. https://doi.org/10.1016/j.jbi.2015.12.013.

Hartholt, K.A., Van Beeck, E.F., Polinder, S., et al., 2011. Societal consequences of falls in the older population: injuries, healthcare costs, and long-term reduced quality of life. J. Trauma 71, 748–753. https://doi.org/10.1097/TA.0b013e3181f6f5e5.

Higgins, J., Green, S., 2011. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [Updated March 2011]. Cochrane Collab. 0. pp. 10–11.

Kovács, É., Tóth, K., Dénes, L., et al., 2012. Effects of exercise programs on balance in older women with age-related visual problems: a pilot study. Arch. Gerontol. Geriatr. 55, 446–452. https://doi.org/10.1016/j.archger.2012.01.009.

Kwok, B.C., Pua, Y.H., 2016. Effects of WiiActive exercises on fear of falling and functional outcomes in community-dwelling older adults: a randomised control trial. Age Ageing 45, 621–628. https://doi.org/10.1093/ageing/afw108.

Kyrdalen, I.L., Moen, K., Røysland, A.S., Helbostad, J.L., 2014. The Otago exercise program performed as group training versus home training in fall-prone older people: a randomized controlled trial. Physiother. Res. Int. 19, 108–116. https://doi.org/10.

1002/pri.1571.
Lacroix, A., Kressig, R.W., Muehlbauer, T., et al., 2016. Effects of a supervised versus an unsupervised combined balance and strength training program on balance and muscle power in healthy older adults: a randomized controlled trial. Gerontology 62, 275–288. https://doi.org/10.1159/000442087.
Liston, M.B., Alushi, L., Bamiou, D.E., Martin, F.C., Hopper, A., Pavlou, M., 2014. Feasibility and effect of supplementing a modified OTAGO intervention with multisensory balance exercises in older people who fall: a pilot randomized controlled trial. Clin. Rehabil. 28, 784–793. https://doi.org/10.1177/0269215514521042.
Liu-Ambrose, T., Donaldson, M.G., Ahamed, Y., et al., 2008. Otago home-based strength and balance retraining improves executive functioning in older fallers: a randomized controlled trial. J. Am. Geriatr. Soc. 56, 1821–1830. https://doi.org/10.1111/j.1532-5415.2008.01931.x.
Maher, C.G., Sherrington, C., Herbert, R.D., Moseley, A.M., Elkins, M., 2003. Research report reliability of the PEDro scale for rating quality of randomized. Phys. Ther. 713–721. https://doi.org/10.1016/s0895-4356(00)00360-7.
McMahon, S.K., Wyman, J.F., Belyea, M.J., Shearer, N., Hekler, E.B., Fleury, J., 2016. Combining motivational and physical intervention components to promote fall-reducing physical activity among community-dwelling older adults. Am. J. Health Promot. 30, 638–644. https://doi.org/10.4278/ajhp.130522-ARB-265.
Moher, D., Shamseer, L., Clarke, M., et al., 2015. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst. Rev. 4, 1–9. https://doi.org/10.1186/2046-4053-4-1.
Morris, J.N., Howard, E.P., Steel, K., et al., 2016. Strategies to reduce the risk of falling: cohort study analysis with 1-year follow-up in community dwelling older adults. BMC Geriatr. 16. https://doi.org/10.1186/s12877-016-0267-5.
National Institute for Care Excellence, 2013. Falls: Assessment and Prevention of Falls in Older People. (PMID: 25506960).
Otaka, Y., Morita, M., Mimura, T., Uzawa, M., Liu, M., 2017. Establishment of an appropriate fall prevention program: a community-based study. Geriatr Gerontol Int 17, 1081–1089. https://doi.org/10.1111/ggi.12831.
Park, Y., Chang, M., 2016. Effects of the Otago exercise program on fall efficacy, activities of daily living and quality of life in elderly stroke patients. J. Phys. Ther. Sci. 28, 190–193. https://doi.org/10.1589/jpts.28.190.
Phelan, E.A., Mahoney, J.E., Voit, J.C., Stevens, J.A., 2015. Assessment and management of fall risk in primary care settings. Med. Clin. N. Am. https://doi.org/10.1016/j.mcna.2014.11.004.
Picha, K.J., Howell, D.M., 2017. A model to increase rehabilitation adherence to home exercise programmes in patients with varying levels of self-efficacy. Musculoskeletal Care. https://doi.org/10.1002/msc.1194.
Picorelli, A.M.A., Pereira, L.S.M., Pereira, D.S., Felício, D., Sherrington, C., 2014. Adherence to exercise programs for older people is influenced by program characteristics and personal factors: a systematic review. J. Physiother. 60, 151–156. https://doi.org/10.1016/j.jphys.2014.06.012.
Robertson, M.C., Campbell, A.J., Gardner, M.M., Devlin, N., 2002. Preventing injuries in older people by preventing falls: a meta-analysis of individual-level data. J. Am. Geriatr. Soc. 50, 905–911. https://doi.org/10.1046/j.1532-5415.2002.50218.x.
Schoene, D., Lord, S.R., Delbaere, K., Severino, C., Davies, T.A., Smith, S.T., 2013. A randomized controlled pilot study of home-based step training in older people using videogame technology. PLoS One 8. https://doi.org/10.1371/journal.pone.0057734.
Schwenk, M., Grewal, G.S., Honarvar, B., et al., 2014. Interactive balance training integrating sensor-based visual feedback of movement performance: a pilot study in older adults. J. Neuroeng. Rehabil. 11, 1–13. https://doi.org/10.1186/1743-0003-11-164.
Sherrington, C., Whitney, J.C., Lord, S.R., Herbert, R.D., Cumming, R.G., Close, J.C.T., 2008. Effective exercise for the prevention of falls: a systematic review and meta-analysis. J. Am. Geriatr. Soc. 56, 2234–2243. https://doi.org/10.1111/j.1532-5415.2008.02014.x.
Sherrington, C., Tiedemann, A., Fairhall, N., Close, J.C.T., Lord, S.R., 2011. Exercise to prevent falls in older adults: an updated meta-analysis and best practice recommendations. N. S. W. Public Health Bull. 22, 78. https://doi.org/10.1071/NB10056.
Sherrington, C., Michaleff, Z.A., Fairhall, N., et al., 2017. Exercise to prevent falls in older adults: an updated systematic review and meta-analysis. Br. J. Sports Med. 51, 1749–1757. https://doi.org/10.1136/bjsports-2016-096547.
Shier, V., Trieu, E., Ganz, D.A., 2016. Implementing exercise programs to prevent falls: systematic descriptive review. Inj. Epidemiol. 3 (16). https://doi.org/10.1186/s40621-016-0081-8.
Shubert, T.E., Goto, L.S., Smith, M.L., Jiang, L., Rudman, H., Ory, M.G., 2017. The Otago Exercise Program: innovative delivery models to maximize sustained outcomes for high risk, homebound older adults. Front. Public Health 5, 1–8. https://doi.org/10.3389/fpubh.2017.00054.
Son, N.K., Ryu, Y.U., Jeong, H.W., Jang, Y.H., Kim, H.D., 2016. Comparison of 2 different exercise approaches: tai chi versus Otago, in community-dwelling older women. J. Geriatr. Phys. Ther. 39, 51–57. https://doi.org/10.1519/JPT.0000000000000042.
Stevens, J.A., Burns, E., 2015. A CDC compendium of effective fall interventions. In: What Works for Community-dwelling Older Adults, 3rd ed. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Atlanta, Georgia.
Thomas, S., Mackintosh, S., Halbert, J., 2010. Does the “Otago exercise programme” reduce mortality and falls in older adults? A systematic review and meta-analysis. Age Ageing 39, 681–687. https://doi.org/10.1093/ageing/afq102.
Verhagen, A.P., De Vet, H.C.W., De Bie, R.A., et al., 1998. The Delphi list: a criteria list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. J. Clin. Epidemiol. 51, 1235–1241. https://doi.org/10.1016/S0895-4356(98)00131-0.
de Vries, N.M., van Ravensberg, C.D., Hobbelen, J.S.M., Olde Rikkert, M.G.M., Staal, J.B., Nijhuis-van der Sanden, M.W.G., 2012. Effects of physical exercise therapy on mobility, physical functioning, physical activity and quality of life in community-dwelling older adults with impaired mobility, physical disability and/or multi-morbidity: a meta-analysis. Ageing Res. Rev. 11, 136–149. https://doi.org/10.1016/j.arr.2011.11.002.
Waters, D.L., Hale, L.A., Robertson, L., Hale, B.A., Herbison, P., 2011. Evaluation of a peer-led falls prevention program for older adults. Arch. Phys. Med. Rehabil. 92, 1581–1586. https://doi.org/10.1016/j.apmr.2011.05.014.
World Health Organization, 2007. WHO global report on falls prevention in older age. In: Community Health, . https://doi.org/9789241563536.
Yang, X.J., Hill, K., Moore, K., et al., 2012. Effectiveness of a targeted exercise intervention in reversing older people's mild balance dysfunction: a randomized controlled trial. Phys. Ther. 92, 24–37. https://doi.org/10.2522/ptj.20100289.
Yoo, H.-N., Chung, E., Lee, B.-H., 2013. The effects of augmented reality-based Otago exercise on balance, gait, and falls efficacy of elderly women. J. Phys. Ther. Sci. 25, 797–801. https://doi.org/10.1589/jpts.25.797.