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Supporting active ageing before retirement: a systematic review and meta-analysis of workplace physical activity interventions targeting older employees

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ABSTRACT

Objective With the growing representation of older adults in the workforce, the health and fitness of older employees are critical to support active ageing policies. This systematic review aimed to characterise and evaluate the effects on physical activity (PA) and fitness outcomes of workplace PA interventions targeting older employees.

Design We searched Medline, PreMedline, PsycInfo, CINAHL and the Cochrane Controlled Register of Trials (CENTRAL) for articles published from inception to 17 February 2020. Eligible studies were of any experimental design, included employees aged ≥50 years, had PA as an intervention component and reported PA-related outcomes.

Results Titles and abstracts of 8168 records were screened, and 18 unique interventions were included (3309 participants). Twelve studies were randomised controlled trials (RCTs). Seven interventions targeted multiple risk factors (n=1640), involving screening for cardiovascular disease risk factors, but had a non-specific description of the PA intervention. Four interventions targeted nutrition and PA (n=1127), and seven (n=235) focused only on PA. Interventions overwhelmingly targeted aerobic PA, compared with only four interventions targeting strength and/or balance (n=106). No studies involved screening for falls/injury risk, and only two interventions targeted employees of low socioeconomic status. Computation of effect sizes (ESs) was only possible in a maximum of three RCTs per outcome. ESs were medium for PA behaviour (ES=0.25 95% CI −0.07 to 0.56), muscle strength (ES=0.27, 95% CI −0.26 to 0.80), cardiorespiratory fitness (ES=0.28, 95% CI −22 to 0.78), flexibility (ES=0.50, 95% CI −0.04 to 1.05) and balance (ES=0.74, 95% CI −0.21 to 1.69). Grading of Recommendations Assessment, Development and Evaluation criteria-rated quality of evidence was 'low' due to high risk of bias, imprecision and inconsistency.

Conclusions The lack of high-quality effective workplace PA interventions contrasts the importance and urgency to improve the health and fitness in this population. Future interventions should incorporate strength and balance training and screening of falls/injury risk in multi risk factors approaches.

Strengths and limitations of this study

- ► This systematic review was registered in PROSPERO.
- ► We followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses reporting guidelines and the Cochrane Collaboration and the GRADE approach to rate the quality of evidence.
- ► We used five databases from inception and backward citation tracking of all included studies.
- ► Pooled effect sizes that were not expressed in similar units, although they measured the same concept, may have artificially increased the heterogeneity of the effect.

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INTRODUCTION

Population ageing poses individual, social, economic and political challenges and is predicted to accelerate even further in the 21st century.[1] The WHO's 'Active Ageing' concept is a leading global policy strategy for successful ageing,[2] particularly influencing retirement policies towards maintaining engagement with paid employment. In the developed world, strategies have been implemented to promote economic activities among aged workers, including incentives for late retirement, penalties for early retirement and an increase in or abolishment of the age of mandatory retirement.[3] Older retirement age means that more employees beyond the age of 55 years will remain in the workforce.[4]

While a number of mental and social abilities can improve with increasing age, and such changes should be viewed as strengths and be respected,[4] age-related physiological decline requires special considerations regarding occupational health, safety and productivity.[5] In-depth reviews on ageing at work[6 7] identified a number of physiological, sensory and psychological differences between older workers and their younger counterparts, including reduced muscle strength, endurance, trunk flexibility and structural and sensorineural degeneration that affect balance, vision and hearing, aerobic capacity, heat tolerance, increased anthropometric risks, psychological exhaustion, anxiety and depression. Furthermore, older employees suffer from greater prevalence of comorbidities, musculoskeletal problems and sickness-related absence and severe injuries.[6 7]

It is well established that regular physical activity (PA) is effective in attenuating age-related physiological declines in all body systems and in preventing and managing many age-related chronic and musculoskeletal conditions.[8–10] Adherence to older adults' comprehensive PA guidelines including balance exercises, muscle strengthening and moderate-intensity aerobic activity is likely to benefit older employees in terms of health as well as work productivity and safety. Hence, recently physical employment standards for older employees have been suggested.[7] The workplace has long been considered a good setting for health promotion, and many PA interventions have been conducted in this setting, with the first systematic review of their effectiveness published in 1998.[11] However, we have not identified any systematic reviews of workplace PA interventions that specifically targeted older employees. PA interventions targeting older adults should additionally include activities to promote muscle mass, strength and balance, which are important for the prevention of sarcopenia, functional disabilities, falls and injuries.[12] A recent systematic review by Poscia *et al*[13] synthesised the evidence on health promotion interventions targeting older employees. However, this review examined a variety of health promotion initiatives and have missed interventions that focused on PA, by only using 'fitness' and 'capacity' as search terms. Given that PA guidelines for older adults include a range of physical outcomes relevant to health beyond cardiorespiratory fitness or capacity, such as muscle strength, balance and flexibility,[14 15] it is important to include broader terms when reviewing health promotion programmes. Furthermore, the main outcomes included in the review by Poscia and colleagues[13] were health status, well-being and work productivity, not PA measures. Thus, the effectiveness of workplace interventions on PA and fitness outcomes of older employees is uncertain.

The objectives of this systematic review were to: (1) identify and characterise workplace PA interventions delivered to employees aged ≥50 years; (2) assess the methodological quality of the studies; and (3) assess the effect of interventions on PA behaviour and fitness outcomes highlighted in PA guidelines for older adults.

METHODS

This review followed guidance published by the Centre for Reviews and Dissemination, the Cochrane Collaboration[16] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[17] (see online supplementary file: PRISMA checklist). The protocol was submitted to the International Prospective Register of Systematic Reviews (PROSPERO) on 21December 2017 and final registration received on 29 January 2018; registration number CRD42018084863 available at https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=84863).

Inclusion and exclusion criteria

We included studies that involved any PA interventions (ie, intervention that will encourage people to move large skeletal muscles) and were delivered at workplaces to employees aged ≥50 years. Studies that included a wider age range, such as whole workplace intervention, were eligible for inclusion if the mean age of participants was at least 50 years. This decision was based on a systematic review of workplace health promotion interventions by Poscia *et al*[13] who included studies that explicitly targeted older employees and found that the mean age of these workers ranged from 51 to 55 years. Interventions could include those related to aerobic PA (eg, walking), stretching, balance, muscle strength, yoga, tai chi, pilates, gym workout, sport or any other form of PA/exercise. Studies that targeted other health risks in addition to physical inactivity (hereafter, multiple risk factors interventions) were only included if PA/exercise was one of the intervention components and a PA-related outcome was reported. Studies with any experimental design (pre–post with or without a comparison group, non-randomised trials, randomised controlled trials (RCTs) and cluster RCTs) were included because of the small number of RCTs anticipated.[13]

Studies were excluded if the PA intervention was not delivered in the workplace (eg, community and health practice), or if the interventions targeted the whole workplace with a wider age range and did not include specific PA-related outcomes.

Search strategies

We systematically searched five databases from inception to 23 December 2017. We then updated our search on 13 June 2019 to include all 2018 and again on 17 February 2020. Included databases were: Medline, PreMedline, PsycInfo, CINAHL and the Cochrane Controlled Register of Trials (CENTRAL). Specific search strategies were developed for each database, using a combination of search terms and subject headings where applicable. All electronic searches included Medical Subject Headings (MeSH) terms and keywords for workplace (eg, occupations and worksite), PA (eg, walking, postural balance and muscle strength) and intervention (eg, health promotion, programme and RCT) and were limited to humans, and age (PsycInfo: 40+ years; all others: 45+ years) (see online supplementary file: search strategy). One reviewer (JS) retrieved the entries from the database using EndNote (V.X9.3.3) and screened the titles and abstracts to identify potential papers for inclusion as well as running backward citation tracking of potential studies selected for full-text review. Two reviewers (JS and DM) independently conducted the final selection of papers based on full text. Disagreements were discussed and resolved by consensus.

Data extraction

Three data extraction formats were used: a table summarising the included studies was created using the subheadings: source, study design, population characteristics, study duration, type of intervention, comparison group and outcomes. A second table describes characteristics of each intervention in terms of recruitment, content, intervention deliverer and process outcomes based on data extracted by DM and SM. A third table summarises the quality of the included papers and another table summarises the effect sizes for each outcome along with the level of evidence of this effect.

Quality assessments and analysis

The Cochrane risk of bias tool for RCTs and additional domains from the tool for assessing risk of bias in non-randomised studies of intervention (ROBINS-I) tool for non-randomised studies with a comparison group were used to assess the quality of individual studies.[18] The domains included were: randomisation sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data and selective outcome reporting. The first two domains were only assessed in RCTs. In non-randomised studies with a control group, the additional domains of confounding and selection bias were assessed. Each domain was assessed independently by two authors (DD and FS) who assigned a rating of either 'low', 'high' or 'unclear' risk of bias. Disagreement was resolved by consensus or, where needed, by consultation with a third reviewer (DM). We used Comprehensive Meta-Analysis software (V.2, Biostat, Englewood, New Jersey, USA) to conduct random effects meta-analyses for each outcome accounting for heterogeneity between studies. The standardised mean difference (SMD) (Hedges' g) was calculated for each meta-analysis, standardised by postscore SD (or its estimate) and calculated using the premean and postmean and SD or, when unavailable, the mean change score and SD Effect sizes were categorised as small (≤0.20), medium (>0.20–0.79) or large (≥0.8).[19] For trials with moderate-to-vigorous intensity PA as the outcome, we used data from accelerometers when possible. For studies reporting energy expenditure as the outcome, we converted the value to minutes of moderate-intensity PA using the population mean body weight and four metabolic equivalents for task for moderate-intensity PA. Statistical heterogeneity was determined by the I^2 and χ^2 tests to measure the proportion of variability between studies and tau-square (T^2) was reported to indicate by how much the true effect sizes vary. We followed the recommendation of the Cochrane Collaboration, which states that tests for funnel plot asymmetry should be used only when there are at least 10 studies included in the meta-analysis.[16] Since we had no more than three studies for each outcome, we did not assess publication bias. Finally, we used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach to rate the overall quality of evidence for each outcome from 'very low' to 'high',[20 21] including a narrative summary of findings for outcomes without meta-analysis.[21] GRADE ratings are based on the domains of risk of bias in included studies, indirectness of evidence, imprecision, inconsistency and likelihood of publication bias.

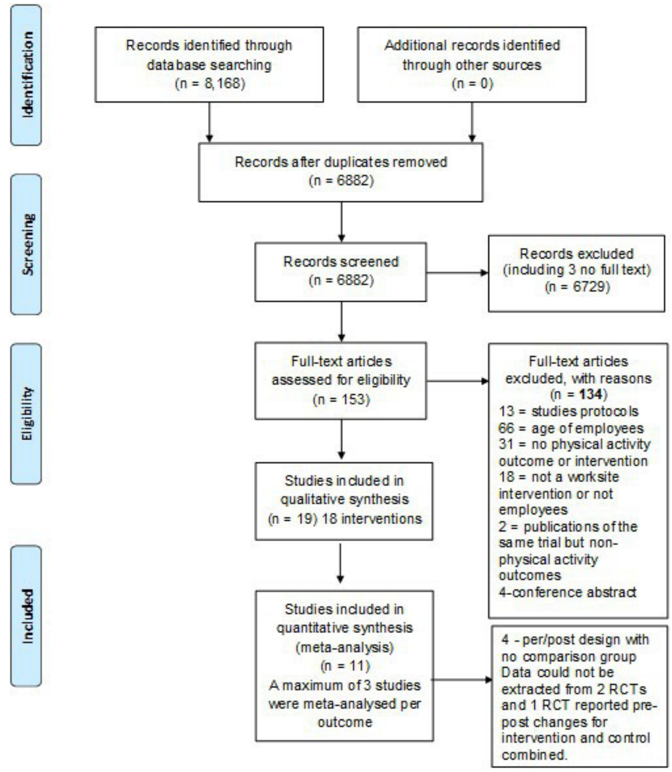

Figure 1 PRISMA flow diagram of selected workplace physical activity intervention studies. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Patient and public involvement

Neither patients nor the public were involved in the design, conduct, reporting or dissemination of this research.

RESULTS

Study selections and characteristics

Our search resulted in 8168 records, which were screened by title and abstract. Of these, 153 were further assessed for eligibility based on full text (figure 1). Nineteen studies met the inclusion criteria; however, two publications referred to the same intervention,[22 23] resulting in 18 unique interventions.

The characteristics of the studies are summarised in table 1. Ten studies were RCTs,[24–33] and two were cluster RCTs—one involving only two worksites[34] and the other

Table 1 Characteristics of the studies that met the inclusion criteria in worksite older employees' physical activity (PA) interventions arranged by design and year

	Design sample	Population	Duration	Intervention description	Comparison	PA-related outcomes
Bassey *et al*[30]	RCT n=108	UK, factory floor workers (blue collar) from light industrial company. Age 55–60 years. 51% males.	12 weeks	PA focus; prescribed aerobic (walking) programme with a goal to increase cardiorespiratory fitness	No intervention	1. Physical condition – heart rate (HR) at walking 4.8 km/hour. 2. Sustained $HR_{4.8km/h}^{-1}$ for at least 7 min. 3. Daily total minutes walked at $HR_{4.8km/h}^{-1}$. 4. Step count.
Sharpe *et al*[35]	Cluster RCT n=250	USA, employees from 'support and academic staff' at the University of Michigan. Age 50–69 years. 53% males.	12 months	Multiple risk factor programme; after health risk screening a face-to-face meeting with health promoter; optional: walking groups at work or use facilities.	Health screening but no exposure to health promotion programme	1. Self-report frequency item with a five-point response format, which was not explained or referenced. 2. Self–reported action taken to improve fitness in the past year 3. Precursors of exercise behaviours (self-efficacy to exercise three times a week and intention to exercise vigorously.
Hughes *et al*[24]	RCT (three arms) n=423	USA, older employees from 'support and academic' staff at the University of Illinois, Chicago. Age ≥55 years. 18% males.	12 months	Multiple risk factor programme to: 1. Enhance wellness one-on-one coaching programme (COACH). 2. A web-based health promotion programme (RealAge).	Printed health promotion materials, programmes and services offered by university or by community organisations.	1. Self-report minutes of moderate-intensity and minutes in vigorous intensity using the Behavioural Risk Factor Surveillance System (typical week – seven questions). 2. The Rapid Assessment of Physical Activity for meeting PA recommendations based on nine items (aerobic muscle training and flexibility, response: yes=1, no=0 combined to total score).
Strijk *et al*[22 25]	RCT n=730	Netherlands, workers from two academic hospitals. Age ≥45 years. Mean age 52.3±4.9 years. 25% males.	6 months	PA and nutrition: Vital@work Yoga session 60 min and workout classes 30 min plus home-based aerobic session.	General healthy lifestyle written information: diet, PA and relaxation.	1. The frequency, duration and intensity of participation in commuting, household, occupation and leisure-time PA using the SQUASH questionnaire. 2. Minutes spent on sport from SQUASH. 3. Accelerometer minutes in MVPA on subsample (GTM1 Actigraph). 4. Aerobic capacity (VO_2 max) was estimated using the UKK 2 km walk test.

Continued

Table 1 Continued

	Design sample	Population	Duration	Intervention description	Comparison	PA-related outcomes
Palumbo *et al*[26]	RCT n=14	USA, female nurses from an academic medical centre in Vermont. Age ≥49 years. 0% males.	15 weeks	PA focus: once a week tai-chi guided classes at work; 45 min and unguided home-based practice 10 mins four times a week.	No intervention	1. Flexibility of trunk 'Sit-and-Reach' test. 2. Strength: isometric knee extensor test with dynamometer. 3. Balance-Functional Reach test (cm).
Cook *et al*[27]	RCT n=278	USA, IT employees from two major global IT companies in California and Boston. Age: 50–68 years. 67% males.	12 weeks	Multiple risk factor web-based educational programme 'HealthyPast50' with no human contact.	No intervention. Wait-listed.	1. Exercise habits: based on Godin LTPA score measuring frequency per week exercising at three levels (mild, moderate and strenuous) and the number multiplied by intensity factor –reported frequency at each level and in total. 2. Exercise self-efficacy score (eight items) four-point scale. 3. Exercise intention.
Low *et al*[28]	RCT n=62	USA, female employees of a busy community hospital, North Carolina, 40–65 years old; mean age 52±6.3. 0% males.	6 months	Multiple risk factor programme to reduce CVD risk as in control, plus weekly motivational sessions by mail or telephone for goal setting.	Risk reduction educational classes; free access to gym on site and walking group.	1. Frequency – days per week of exercising. 2. Minutes per session of exercising. 3. Level of intensity: no exercise, leisurely, moderate or vigorous exercise (reported as %). 4. Readiness to change exercise.
Granacher *et al*[34]	Cluster RCT n=32	Switzerland, sedentary office workers from two large companies in Basel. Age ≥50 years. 37% males.	8 weeks	PA focus; progressive balance and strength training at the office using exercise charts to perform three times a day; each session lasts 8 min.	No intervention	1. Balance (static) postural control using balance platform, standing on one leg 30 s eyes open–displacement of COP. 2. Gait variability and speed on special treadmill 3. Force jumping height measured on a force platform. 4. Maximal isometric and isokinetic torque (60° and rate of torque development of the plantar flexor using force platform.
Kocur *et al*[29]	RCT n=44	Poland, female administrative and academic office workers from four higher education institutions in Poznań. Age 50–60 years. 0% males.	12 weeks	PA focus - Nordic walking training programme three times a week for 1 hour each.	No intervention	1. Perceived Pain Threshold of upper body (kg/cm^2) (ie, the minimum force that can be applied that induced the feeling of pain) using an electronic pressure algometry. 2. Flexibility (shoulders) using back scratch: measuring how close the hands can be brought together behind the back.

Continued

Table 1 Continued

	Design sample	Population	Duration	Intervention description	Comparison	PA-related outcomes
Chopp-Hurley *et al*[31]	RCT n=24	Canada, Hamilton University employees (McMaster) with clinical osteoarthritis. Age >50 years. 21% men.	12 weeks	PA focus – specific osteoarthritis exercises: static leg strengthening (eg, yoga poses) three to four times a week 07:00–08:00.	No intervention	1. Hip and knee strengths measured by dynamometer; the peak extension and flexion torque out of five trials were recorded normalised to body weight. 2. 6 min walking test. 3. Lower limb strength: chair sit to stand during 30 seconds 4. Timed up and go test. 5. 40 m fast paced (time to complete).
Bergman *et al* 2018 [32]	RCT n=80	Sweden, Umea office workers (13 companies). Overweight and obese. Age 40–67 years. (Mean age 51 years). 45% males.	13 months	PA focus – treadmill workstation recommended to walk 1 hour a day at moderate intensity but no jogging.	Working as usual at their sit-and-stand working desk	1. Daily walking time at weekdays and weekend measured by ActiPAL accelerometer. 2. Number of steps ActiPAL. 3. Time spent in moderate to vigorous PA by Actigraph accelerometer. 4. PA bouts of more than 10 mins on weekdays and weekend.
Qi *et al*[33]	RCT n=40	Queensland, Australia University insufficiently active office workers. Age 55–77 (mean 59.6) years. 22% males.	12 weeks	PA focus tai chi movements (10) performed with resistance band (Theraband) three times per week 45 min per session on-site. Employee could choose from eight different time slots.	Active control: tai chi only without the Theraband in different room to intervention. Similar number of sessions were offered.	1. Lower limb strength using chair sit to stand during 30 s. 2. Balance-Functional Reach test (cm). 3. Hand grip strength. 4. 2 min walk test (work capacity).
Chen *et al*[37]	Quasiexperiment (individual allocation) n=108	Taiwan, workers from small-scale and medium-scale enterprises. Age ≥50 years. 45% males.	6 months	Multiple risk factors; onsite educational workshops during first 4 weeks+meetings with OHN to set goals, plans and on-site group support.	Only educational workshops in the first 4 weeks.	1. Frequency: number of times per week doing PA using Taiwan Longitudinal Study on Ageing - no information on the PA domains asked (eg, leisure, work, etc). 2. Sedentary time (hours/day).
Arao *et al*[36]	Quasiexperiment (cluster allocation) n=197	Japan, employees working in five sites of two factories in Tokyo who had at least one CVD risk. Age 40–59 years (mean age=55). 0% females.	6 months	PA and nutrition (LiSM-PAN) multicomponents programme; individual counselling 5×10 min around goals; social and environmental support.	Feedback from the medical check-ups plus recommendations on diet and PA including printed materials on exercise, healthy diet and cooking.	1. Self-report energy expenditure (kcal/week) derived from the leisure time exercise was assessed by the Kuopio Ischaemic Heart Disease Risk Factor Study. 2. Maximum oxygen uptake. 3. VO_2max (mL/kg/min) from a submaximum bicycle test (Astrad). 4. Stage of change for exercise.

Continued

Table 1 Continued

	Design sample	Population	Duration	Intervention description	Comparison	PA-related outcomes
Abbas *et al*[38]	Pre–post n=665	UK, low-paid local government employees from socially and economically deprived areas in NE England. Age ≥40 years, mean age 50.5±6.4. 37% males.	9 months	Multiple risk factor health screening staging risk level and referrals to exercise, weight management, smoking cessation, promotion of mental health and alcohol reduction.	Not applicable	1. Participation in aerobic exercise dichotomised to not meeting recommendation (less than five times a week of less than 30 min session). 2. Referred to exercise question on doing exercise outside work (report on % before and after).
Naug *et al*[39]	Pre-post pilot trial n=33	Australia, bus drivers from two depots of South East Queensland. Age: 50–68 years. 64% males.	6 weeks	PA and nutrition, group educational sessions; harm of sitting, healthy eating and exercise; PA – pedometer to track steps.	Not applicable	1. Exercise levels – no report on questionnaire type; researcher-driven classification: (A) none (no exercise), (B) moderate level (eg, 30–40 min walking twice a week or tennis once a week), (C) intense (eg, gym four to seven times/week or cycling 5 days/week), sedentary behaviour (hours/week).
Scapellato *et al*[40]	Pre–post n=167	Padua, Italy healthcare workers at risk of CVD. Mean age 50±7.3 years. 31.7% males.	6 months	PA and nutrition, brochure on exercise and motivational counselling on site at baseline and midterm by phone.	Not applicable	1. PA MET based on a 4-day diary about the type of activity, frequency (day per week) and duration (min).
Edman *et al*[41]	Pre–post pilot trial n=54	Philadelphia, USA healthcare hospital workers volunteered with at least one CVD risk. Mean age 53.3±10 years. 5% males.	another 12 week cycle of 6 sessions.	Multiple risk factor programme – six sessions of health coaching face-to-face or by phone including goal setting, education and motivational strategies.	Not applicable	1. Self-reported change in number of sessions per week exercising aerobically for at least 20 min. 2. Self-reported number of times per week doing muscle strengthening exercise for at least 20 min.

COP, centre of pressure; CVD, cardiovascular disease; GHQ, General Health Questionnaire; LiSM, lifestyle modification; MET, metabolic equivalent; MVPA, moderate-to-vigorous physical activity; OHN, occupational health nurse; RCT, randomised controlled trial; SQUASH, Short Questionnaire to ASsess Health – enhancing physical activity; UKK, The Finnish Urho Kaleva Kekkonen walking test.

several university units.[35] There were also two non-randomised studies[36 37] and four pre-evaluations and postevaluations with no comparison group.[38–41]

Participants

In total, 3309 participants (of those 2085 participated in RCTs) were included in the 18 worksite PA interventions: six in the USA,[24 26–28 35 41] two in the UK,[30 38] two in Australia[33 39] and one each in Taiwan,[37] Japan,[36] Poland,[29] the Netherlands,[22 25] Switzerland,[34] Canada,[31] Sweden[32] and Italy.[40]

Five interventions were delivered in academic institutions,[24 29 31 33 35] four in hospitals or medical centres[25 28 40 41] and four were delivered to factory employees.[30 36–38] One intervention was delivered to transport workers (drivers),[39] and four were delivered to office workers.[27 32–34] Most studies (n=12) targeted both genders, with a high percentage of male participants (>60%) in transport[39] and IT workplaces,[27] and fewer male participants (5%–25%) in academic / administrative[24] and medical occupations.[25 31 41] Three interventions targeted females only[26 28 29] and one intervention targeted males only.[36]

Characteristics of PA interventions

PA types and targeted fitness area

Table 2 summarises the characteristics of the interventions (more details are provided in online supplemental table 1). Interventions overwhelmingly focused on aerobic PA and five studies targeted muscle strength, balance and flexibility; one study delivered a combination of progressive balance and muscle strengthening,[34] two studies focused on tai chi[26 33] and two studies focused on yoga classes.[23 31]

Seven studies addressed multiple cardiovascular risk factors,[24 27 28 35 37 38 41] four targeted PA and nutrition[25 36 39 40] and seven focused only on PA.[26 29–34] Nearly all multiple risk factor interventions used a generic description of the PA intervention such as 'exercise on their own',[35] 'exercise training',[28] referrals to exercise classes[38] or choosing PA goals.[24 27] In the studies by Hughes *et al*[24] and Low *et al*,[28] the interventions also offered on-site self-managed activities such as walking groups or using workplace exercise facilities.

In addition, in these multiple risk factor interventions, some forms of 'risk assessment', such as a nurses' check-up for cardiovascular disease (CVD) risks, were applied before the targeted behaviour was selected by or for participants[38] or self-appraisal of risk using questionnaires,[24 27] or assessment carried out during the first educational session.[37 41] No study assessed risk of falls or injuries.

The PA and nutrition interventions focused on aerobic regimens such as steps accumulation,[25 36 39] counselling to shape PA goals[40] or an aerobic workout on-site.[25] The study by Strijk *et al*[25] also offered yoga sessions, an activity that is recognised as multidimensional and which enhances muscle strength, balance and mobility, but these fitness outcomes were not assessed.[42]

The PA-only interventions either focused on aerobic regimens, such as use of a treadmill workstation,[32] self-managed aerobic walking[30] or Nordic walking.[29] Although Nordic walking is primarily aerobic activity, it can also increase upper body strength and flexibility (table 2); we, therefore, consider the study multidimensional.[29] Two studies offered tai chi classes, which is also considered multidimensional PA (tai chi).[43] One study invited older office employees to novel tai chi combined with Thera-band exercises, adding progressive strength training to tai chi.[33] The other study offered tai chi classes to nurses as part of a wellness programme.[26] The study by Granacher *et al*[34] offered progressive strength and balance exercises performed in the office. At the beginning of each week, the trainer introduced the series of exercises to be performed three times a day, 5 days a week.

Delivery modes

Three delivery modes were noted (table 2). In eight studies (mostly PA only interventions), the PA intervention was delivered on-site during working hours,[25 26 28 29 32–34] or on-site but before working hours,[31] in six studies participants were counselled in the workplace in face-to-face meetings,[35–37] or by telephone calls (COACH-arm),[24] or a combination of both,[40 41] but the PA sessions took place in employees' discretionary time. In four studies, the PA was self-managed with little or no supervision.[27 30 38 39] The study by Hughes *et al*[24] had two intervention arms: one involved personal contact with students trained in behaviour change coaching ('COACH'), while the other arm was self-managed through a web-based intervention ('RealAge') with no other contact.[24] The study by Cook *et al*[27] was also a web-based self-managed intervention (HealthyPast50).

Intervention duration and compliance

Eight interventions were short term, ranging from 6 to 15 weeks.[26 27 29–31 33 34 39] Seven interventions lasted between 5 and 9 months,[25 28 36–38 40 41] and three interventions lasted 12–13 months.[24 32 35] All studies provided data related to intervention retention rates (ie, withdrawals) with the exception of one pre–post study.[38] Seven studies did not report intervention compliance (eg, attendance at classes and recorded logs). Studies of short duration also reported higher compliance (>75%) compared with studies with medium or long duration. Four studies reported on programme implementation fidelity.[24 26 38 40]

Intervention reach

Programme reach (ie, proportion of study population recruited to the trials) varied substantially. When recruitment methods involved a targeted strategy based on prior 'screening for eligibility criteria', a strategy reported in five studies,[30 36–38 40] intervention reach was highly variable. In the Japanese study, 92% of the targeted eligible employees were recruited,[36] while two interventions in

Table 2 Summary of the characteristics of workplace physical activity (PA) interventions delivered to older employees (18 studies)

	Multiple risk factors including physical inactivity							PA and diet				PA only						
Intervention characteristics	**Abbas 2015[38]**	**Chen 2016[37]**	**Cook 2015[27]**	**Hughes 2011[24]**	**Low 2015[28]**	**Sharp 1992[35]**	**Edman 2019[41]**	**Arao 2007[36]**	**Strijk 2011–12[22 23]**	**Naug 2016[39]**	**Scapel-lato 2018[40]**	**Bassey 1983[30]**	**Grana-cher 2011[34]**	**Palum-bo 2012[26]**	**Kocur 2017[29]**	**Chop hurley 2017[31]**	**Berg-man 2018[32]**	**Qi 2019[33]**
Aerobic workout, walking and steps accumulation				×	×	×		×	×	×		×	×				×	
Nordic walking															×			
Balance exercise													×					
Muscle strength													×			×		×
Flexibility																		
Multidimensional PA									Yoga					Tai chi		Yoga poses		Tai chi+
Generic description 'exercise goals', referral to class	×	×	×	×	×	×	×				×			×				
Delivery mode	SM	IC	SM	IC/SM	OS	IC	IC	IC	OS	SM	IC	SM	OS	OS	OS	OS	OS	OS
Duration	M	M	S	L	M	L	M	M	M	S	M	S	S	S	S	S	L	S
Recruitment method	TS	TS	WA	WA	WA	WA	WA	TS	WA	I	TS	TS	I	WA	WA	WA	I	WA
Process outcomes	R: 64%. C: no report. F.	R: 96%. C: no report. Q.	R: 80%. C: 72%.	R_{arm1}: 91%. R_{arm2}: 51%. C_{arm1}: 97%. C_{arm2}: 57%. F.	R: 28% C: means socio economic status (ses)/ week very poor.	R: 63%. C: 73%.	R: 70%. C: mean ses/per trial 7.5 out of 12.	R: 95%. C: 55%.	R: 80%. C: 73%.	R: 64%. C: no report. Q.	R: 53%. C: no report. F.	R: 54%. C: 33%.	R: 100%. C: 99%.	R: 71%. C: 82%. F.	R: 91% C: no report.	R: 75%. C: means ses/week 1.2 (poor)	R: 85%. C: no report.	R: 75%. C: no report.
PA-related outcomes	NA	+	+	–	–	–	NA	+	-	NA	NA	+	$+_1$	+	$+_1$	$+_1$	+	+
Included in meta-analysis	No	Yes	Yes	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes

–, no significant between group effect on PA measure; $+_1$, significant between groups positive effect in favour of intervention only in one PA-related outcome ; +, significant between groups positive effect/s in favour of interventions; C, compliance % from ideal target; F, fidelity of intervention delivery; I, information sessions and volunteers to take part; IC, individualised counselling; L, long >9 months; M, medium 5–9 months; NA, if no comparison group ; OS, on site PA sessions; Q, qualitative comments; R, retention of intervention participants; S, short ≤15 weeks; SM, self-managed programme; TS, targeted strategy (eg, screening); WA, worksite advertisement emails, posters and word of mouth inviting participation.

the UK,[30 38] the Taiwanese study[37] and the Italian study[40] using the same strategy achieved much lower recruitment rates (ranging from 20% to 35%). In the 10 studies that used workplace advertisement as the method of recruitment,[22 24 26–29 31 33 35 41] only two studies reported on the reach of the programme: Strijk *et al*[25] invited all employees listed in the targeted age range (n=3756) and indicated that 27% of those agreed to participate. Cook *et al*[27] offered a financial incentive ($25) for completing the baseline survey, which 96% of the employees aged >50 years did, resulting in 276 participants.[27] The rest of the studies either did not report or could not estimate reach because key information, such as the number of eligible potential participants exposed to the advertisement, was missing.

Study quality

Included RCTs and non-randomised studies were mainly of poor quality (online supplemental table 2 and online supplemental figure 1). In five of the RCTs, the randomisation was poorly described, and in seven of the RCTs, the concealment of allocation was poorly described. Only 5 out of 12 RCTs were deemed at a 'low risk' of selection bias.[25 27 31 32] Performance bias is expected due to inability to blind participants, as would be expected in trials involving behaviour modification. Four of the 12 RCTs relied only on self-reported PA-related outcomes,[24 27 28 35] resulting in a high risk of ascertainment bias. Eight trials included objective measures of PA or fitness outcomes; of those, four involved less than 40 participants.[26 29 31 34] An additional major concern was the risk of selection bias due to attrition given that most trials (78%) had incomplete outcome data, and intention-to-treat analysis was done in only five RCTs.[25 27 31 32] The two included studies that were not RCTs had a high risk of bias in three, respectively four out of the five domains.

Effectiveness of interventions

Two studies assessed PA behaviour but were not included in meta-analysis as we could not extract SMD from the mixed model with interaction, both reported no-between groups difference.[24 35] Another RCT assessed changes in daily walking on half of the sample but reported the pre–post changes for the intervention and control group combined and therefore was not included in meta-analysis.[30] Table 3 summarises the effect of the interventions on PA behaviour and fitness outcomes, including pooled effect sizes that are also presented in online supplemental figure 2. Overall, no pooled outcomes showed statistically significant differences between intervention and control groups.

Three studies that examined PA/exercise frequency[27 28 37] had a pooled SMD of 0.25 (95% CI −0.07 to 0.56) and moderate heterogeneity (I^2=53%, p=0.19). Time spent in moderate-to-vigorous PA was computed from the studies using accelerometers[25 32] and the study by Arao *et al*,[36] which used self-report. All these studies presented results at 6-month follow-up. The pooled SMD was 0.22 (95% CI −0.05 to 0.50) with acceptable heterogeneity (I^2=46%, p=0.16).

Aerobic fitness using VO_2 max was assessed in two studies[25 36] with a pooled SMD of 0.28 (95% CI −0.22 to 0.78) and high heterogeneity (I^2=82%, p=0.02); in the study by Strijk *et al*,[25] a small proportion of the sample took the test, introducing performance bias. In the study by Arao *et al*,[36] the participants were not randomised, introducing potential selection bias and confounding.

Two small-scale studies (n=57) reported the effect of the intervention on muscle strength (ie, plantar strength and knee flexor) with an SMD of 0.27 (95%CI −0.26 to 0.80).[31 34] Another study included isometric knee extensor strength as an outcome, but did not provide data, suggesting selective reporting.[26] Three small-scale studies (n=46) reported on static balance (measured by postural control[34] and functional reach[26 33]) with a non-significant medium pooled effect size (SMD=0.74, 95% CI −0.21 to 1.69) and high heterogeneity (I^2=74.3%, p=0.069). Two studies (n=58) examined the effect of the intervention on flexibility in trials of tai-chi[26] and Nordic walking[29] and found a moderate effect size (0.50) without heterogeneity but that was also statistically non-significant (95% CI −0.04 to 1.05).

GRADE ratings of the certainty or quality of evidence for each outcome were low, mostly due to the high risk of bias of included studies, high heterogeneity (inconsistency) and imprecision (all pooled CIs included 0 and were statistically non-significant).

DISCUSSION

To our knowledge, this is the first systematic review and meta-analysis of workplace PA interventions specifically designed for older employees. Although some interventions demonstrated a significant effect on one fitness outcome, collectively, we found no definitive evidence on effectiveness as pooled effects remained non-significant. The methodological quality of the studies was generally low. Only one pre–post study examined whether participants met aerobic recommendations,[38] and only four small-scale trials focused on balance or muscle strength as any outcomes, and all were pilot studies.[29 31 33 34] No programme fully addressed the WHO PA older adults' guidelines, which highlight the need to incorporate balance exercises (≥3 times a week) and muscle strengthening (≥2 times a week) along with the aerobic recommendations of a minimum of 150 min per week of moderate-to-vigorous PA. Therefore, there is a noticeable mismatch between the aims and outcome measures of interventions and those recommended as ideal for older adults. Additionally, this review of the literature suggests that the initial levels of participation (ie, intervention reach) was mostly low, which was also noted in another systematic review of workplace health promotion interventions.[44]

High heterogeneity makes the pooled estimates difficult to interpret as it is unclear whether population

Table 3 Pooled effect sizes for PA behaviour and fitness outcomes with GRADE rating of evidence in trials with comparison group

PA outcomes References	Pooled effect size Standardised mean difference	Numbers (studies)	Quality of evidence (GRADE)*	Comments related to GRADE and SMD
Frequency PA/exercise (per week)[27 28 37]	SMD=0.25 95% CI −0.07 to 0.56 Heterogeneity=54%, p=0.114 T^2=0.0419	n=448 (three studies)	Very low ⊕OOO Serious methodological limitations; serious indirectness; inconsistency with studies not included.	All interventions were multiple risk factors and were self-managed; the exact nature of the exercise intervention and the goals set for people were unclear, limiting attribution of increases to the intervention. The RCT by Sharpe *et al*[35] was not included as it was not possible to extract SMD from the mixed model.
Moderate-to-vigorous physical activity [25 32 36]	SMD=0.22, 95% CI −0.05 to 0.50 Heterogeneity=46.2%, p=0.16 T^2=0.079	n=404 (three studies)	Low ⊕⊕OO Two RCTs used accelerometer data and one self-report non-randomised trial and therefore reduced overall quality.	Additional study by Hughes *et al*[24] was not included as it was not possible to extract SMD from mixed model with interactions term. The study reported no between-groups significant effect.
Aerobic fitness, VO_2 max[25 36]	SMD=0.28 95% CI −0.22 to 0.78 Heterogeneity=82%, p=0.019 T^2=0.1069	n=389 (two studies)	Low ⊕⊕OO Serious methodological limitations; inconsistency.	Strijik *et al*[25] had high loss for this measure and high risk of performance and ascertainment bias; Arao *et al*[36] was a non-randomised controlled trial with high risk of bias due to confounding.
Balance[26 33 34]	SMD=0.74 95% CI −0.21 to 1.69 Heterogeneity=74%, p=0.020 T^2=0.4980	n=86 (three studies)	Low ⊕⊕OO Serious methodological limitations; serious imprecision; inconsistency.	Granacher *et al*[33] used balance platforms that has greater precision and also measures horizontal and vertical planes. Palumbo *et al*[26] and Qi *et al*[33] only measured horizontal displacement (functional reach).
Muscle strength[31 34]	SMD=0.27 95% CI −0.26 to 0.80 Heterogeneity=0%, p=0.380 T^2=0.000	n=57 (two studies)	Low ⊕⊕OO Serious methodological limitations; serious imprecision.	The trial by Palumbo *et al*[26] was not included despite listing isometric knee extension because the results were not presented (selective reporting). Chopp-Hurley *et al*[31] recruited older employees with osteoarthritis; Granacher *et al*[34] did not provide information to judge the trial quality.
Flexibility[26 29]	SMD=0.50 95% CI −0.05 to 1.05 Heterogeneity=0%, p=0.366 T^2=0.000	n=58 (two studies)	Low ⊕⊕OO Serious methodological limitations; imprecision.	In both RCTs (by Plumbo *et al*[26] and Kocur *et al*[29] the randomisation process was unclear; small sample sizes and high risk of performance bias and selective reporting.

*High quality: further research is very unlikely to change our confidence in the estimate of effect. Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Very low quality: we are very uncertain about the estimate.
GRADE, Grading of Recommendations Assessment, Development and Evaluation; PA, physical activity; RCT, randomised controlled trial; SMD, standardised mean difference.

characteristics, intervention implementation or methodological quality issues underlie the heterogeneous results across studies. For example, two cluster RCTs reported changes at 6 months in predicted maximal oxygen uptake: the Japanese study reported a significant medium effect size based on a submaximal stationary bike test[36] and the Dutch study[25] reported a small non-significant effect on the 2 km walking test. The difference between these two measures could explain the high heterogeneity as well as differences related to the completion rate; high in the Japanese study (85% and 93%) and low in the Dutch study (56% and 66%) in the control and intervention groups, respectively.

Multiple risk factor interventions incorporated screening for cardiovascular risk factors but did not address other age-related health problems, such as falls, which are preventable by appropriate exercise.[10 14] Such screening could be carried out either through a single self-report question (eg, history of falls) or through assessment of physiological fall risk (eg, poor balance and impaired leg strength). Risk of falls and related injuries is an important safety issue because the consequences of falls and injuries are greater in older employees compared with their younger counterparts.[6] Furthermore, despite emerging evidence that resistance training is as beneficial as aerobic training for the prevention and management of cardiometabolic risks,[45 46] none of the multiple risk factor interventions explicitly included muscles strength training to reduce CVD/metabolic risk. Muscle strength training was promoted to employees with osteoarthritis, in accordance with clinical guidelines,[31] but only one intervention specifically targeted muscle strength to generally healthy older employees,[34] supporting the recent claim that strength training has been a neglected aspect of PA promotion.[47] From the mid-1940s onwards, each decade adults lose 14%–16% of their isokinetic leg strength,[48] which is a greater decline than that observed in cardiovascular capacity (~10% per decade).[49] Considering that employees aged 50 years and over are likely to stay at work for another decade or more, neglecting this domain is unwarranted. In fact, tests of older university employees (mean age 63 years; n=258) in Brazil found that 55.8% and 6.3% of them were classified in the 'sarcopenia' and 'severe sarcopenia' groups, respectively. In the same study, the prevalence of frailty was 9% and 63% were classified as 'pre-frail'.[50]

The included PA programmes varied substantially in terms of the PA modality, delivery methods and duration. Interestingly, compared with self-managed programmes carried out in participants' discretionary time, on-site supervised sessions during the workday[25 26 29 33 34] tended to demonstrate high retention rates (71%–100%) and good compliance. However, these programmes were usually shorter in duration (less than 15 weeks). On-site

Table 4 Recommendations for the conduct and reporting of future workplace interventions targeting older adults

Aspect	Recommendation
Reach and recruitment	1. To enable calculation of the reach of workplace interventions, we suggest that as a first step employers will endorse the intervention and provide the list of all employees or at least the number of the potential target population (eg, age or year prior to retirement). It may also boost recruitment when the management of the workplace endorses such intervention.
Population	2. Expand the current target population (ie, mostly university and healthcare staff) to include a broader range of occupations, including manual jobs and workers from low socioeconomic status (SES) background. This is important for increased generalisability and reducing gaps between high and low SES workers in lifestyle behaviours after retirement.
Intervention content	3. Incorporate strength, balance and flexibility training along with aerobic activities. 4. Moving interventions from a 'pilot' stage to larger trials and scalable programmes. 5. Intervention targets should include screening for falls and injury risk, frailty and sarcopenia. 6. Improve the reporting on the nature of PA interventions. For example, for interventions that involve a referral to a gym or other facility, describe precisely what exactly these referrals included: advice only, a written programme,or a gym membership. 7. Improve reporting of the intervention using a standard checklist (TIDieR) including implementation fidelity of interventions.
Study methodology	8. Cluster RCTs should include several clusters (workplaces) and should adjust for cluster effect. 9. Studies should assess confounders and adjust for their presence. 10. Interventions that incorporate multidimensional activities (eg, yoga, tai chi and dance) should assess the fitness outcomes specific to be improved by these activities (leg strength, balance and gait speeds). Standardising measures across studies will increase the of studies included in future meta-analyses. 11. Improving the conduct /reporting of RCTs in terms of methods of randomisation, concealment of allocation, blinding the assessors and analysts, reporting results for all randomised participants first before any ad hoc analyses and including objective measures of PA.
Duration and sustainability	12. Consider intervention beyond 6 months and evaluation of maintenance beyond a year.

PA, physical activity; RCTs, randomised controlled trials.

pragmatic approaches, such as treadmill workstations, short breaks for balance and strength training or web-based interventions, can be easily integrated into the workday. However, the effectiveness of treadmill workstations was disappointing,[32] and the collective evidence for other approaches was inconsistent.[24 27 34] These interventions should be further tested by high-quality replication studies before translational research can be conducted.

Multiple risk factor interventions mostly had poor description of the PA component of the intervention that reduced their reproducibility. For example, referrals to exercise lacked specifications of the type of exercise programmes that were available to clients, or goal settings lacked descriptions of how goals were tailored to individuals, how they were monitored and by whom. In addition, most studies rarely reported the fidelity of the interventions. Hence, it is recommended to use a template for reporting of PA interventions, such as Template for Intervention Description and Replication (TIDieR),[51] in order to allow better replication of sensible effective PA interventions.

It is worth noting that about 40% of the interventions were conducted in universities or academic hospitals/clinics. This could possibly be due to ease of doing research in these settings coupled with environments that are conducive to health promotion messages, such as healthcare providers or academics. Hence, the generalisability of intervention implementations and the findings of these studies is limited.

A concerning finding is the poor quality of the RCTs we identified. The study quality could be improved by appropriate randomisation, intention-to-treat analysis and the use of both objective and self-report measures of PA. For example, most multiple risk factor interventions included objective measures of CVD risks (ie, blood tests or anthropometrics) but failed to use objective fitness tests or activity trackers (eg, pedometer and accelerometer). Furthermore, to improve the directness of evidence (ie, outcome measure reflects the fitness dimesion expected to be improved by the PA type promoted in the intervention), such as measuring balance and strength outcomes in interventions involving yoga or tai chi or aerobic fitness in Nordic walking interventions.

Research demonstrates increases in leisure-time PA after transition to retirement compared with during full employment.[52 53] However, a systematic review has found disparities by socioeconomic status (SES); employees with low SES tend to be less active after retirement, whereas those with high SES tend to be more active after retirement.[53] Focus groups with older retirees revealed that retirees from lower SES appeared to place lower value on the importance of leisure-time PA.[54] Therefore, improving PA while in the workforce may be of even greater importance to older people with low SES. In this review, we identified three studies that specifically targeted low paid employees in manual occupations (ie, factory employees) in Japan[36] and the UK.[30 38] Only the study from Japan, which included social and environmental support in addition to behavioural counselling, demonstrated significant positive effects. However, this was a non-randomised study with a high risk of bias for almost all bias domains. Further work is therefore needed to ascertain what types of interventions can most effectively improve PA outcomes in older employees with low SES.

Strengths and limitations

This review applied guideline-informed, rigorous methods to synthesise and evaluate the current evidence on workplace PA interventions for older employees. Compared with the 2016 systematic review by Poscia and colleagues,[13] we have expanded on the list of workplace health promotion interventions delivered to older employees by 11 studies[28–32 34–36 38–40] by carrying out a more sensitive and comprehensive literature search. However, some limitations need to be acknowledged: first, we limited our search to electronic databases that can result in missing unpublished workplace interventions. Second, studies tended to apply different measures or used different units for similar measures. Despite our best attempt to harmonise measures (eg, converting kcal to minutes of at least moderate-intensity PA), comparability across studies is still limited and may explain the high heterogeneity; for example, measuring postural control by balance platform as opposed to a functional reach test. In addition, the current evidence base is limited by the number of studies included for each PA outcome and the quality of existing studies. Based on these limitations, we have mapped out research gaps and suggestions for the conduct and reporting of future interventions targeting older employees (table 4).

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