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Effect of sport on health in people aged 60 years and older: a systematic review with meta-analysis

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ABSTRACT

Objectives To summarise evidence of benefits of sport for health among people aged 60+.

Design Systematic review with meta-analysis of randomised controlled trials (RCTs).

Data sources Medline, CINAHL, SPORTDiscus, the Physiotherapy Evidence Database from inception to April 2021.

Study selection RCTs investigating the effect of sport on health-related outcomes in people aged 60+ compared with non-active control.

Data synthesis and analysis Pooled effect sizes were calculated using random-effect models. Standardised mean differences (SMD), and mean difference (MD) were calculated. The Grading of Recommendations Assessment, Development and Evaluation system was used to assess the certainty of the evidence for analyses with ≥ 3 studies.

Results Nine trials (628 participants) reported in 15 articles were included. Participation in sport improved cardiorespiratory fitness ($n=5$ trials; SMD=0.43, 95% CI 0.17 to 0.70; low certainty evidence), physical function ($n=4$; SMD=0.62, 95% CI 0.05 to 1.18; very low certainty evidence), and mental health ($n=2$; SMD=0.28, 95% CI 0.06 to 0.51) and reduced fat mass ($n=6$; MD=−0.99 kg, 95% CI −1.75 kg to −0.23 kg; low certainty evidence) among older people. We found no significant effects of sport on overall physical activity participation, strength, balance, lean mass and bone mineral density (BMD). One study investigating quality of life reported a positive, but non-significant effect of sport.

Conclusion Sport may have a positive impact on health outcomes in people aged 60+. There was uncertainty on the effect of sport on strength, balance, lean mass and BMD. Further research is needed to investigate the optimal type and dose of sport to maximise the long-term benefits among older people.

INTRODUCTION

The demographic profile of the global population is ageing rapidly. People aged 60 years and older are forecast to total 2 billion by 2050, outnumbering adolescents and young people for the first time in history.^{1 2} As this demographic transition will affect almost all aspects of society, the WHO has recently launched the Decade of Healthy Ageing 2021–2030 to foster long and healthy lives among older people.³ Ageing is strongly associated with the onset of non-communicable diseases (NCDs),^{4 5} and preventive strategies that address the main risk

factors for NCDs, such as physical inactivity, are crucial.

Being physically active throughout life is key to maintaining health, optimising physical function, independent living and enhancing satisfaction with life and the ageing process.^{6–10} To achieve the health benefits of physical activity, including functional capacity and preventing falls, the WHO 2020 Guidelines on Physical Activity and Sedentary Behaviour recommend that older adults undertake 150–300 min of moderate intensity, or 75–150 min of vigorous-intensity physical activity per week.¹¹ The WHO¹¹ and other international exercise consensus statements^{10 12} support the prescription of structured exercises for older people, including resistance and aerobic training activities, as well as multicomponent physical activity that emphasises functional balance and strength training, on at least 2 days of the week. The WHO recommendations endorse that some physical activity is better than none, but more physical activity is better for maximising health outcomes.¹¹ Although it is still unclear what type or domain of physical activity impacts specific health outcomes, it is known that physical activity accumulated at leisure, work, home and during transportation counts towards the WHO recommended amounts.¹¹

Sport is a type of leisure-time physical activity² and it could be an appealing and enjoyable option for older people to be physically active. Many people aged 60+ participate in sport. For example, the AusPlay survey of over 117 000 Australian adults revealed that around 40% of people aged 65+ years participate in organised sport.¹³ Different sport versions can cater for older people at different physical function levels, and modified versions of sport now exist to accommodate the skills and abilities of older people, including people with lower physical function, such as walking football and walking basketball.

The four domains of physical activity are work, active transport, household and leisure. Sport is a type of leisure-time physical activity, and it is worth being investigated as an option of intervention to promote physical activity. Although the health benefits of other forms of leisure-time physical activity, such as walking, have been extensively studied, sport participation has not been widely explored as a physical activity opportunity for older adults.^{14 15} Our previous scoping review¹⁵ of physical activity interventions for older adults identified a lack of reviews investigating the impact of sports in older people. To fill this knowledge gap, we aim

Review

to summarise the evidence on the effect of sports-based interventions on health outcomes among people aged 60 years and older. This systematic review is a component of work on the best available evidence for the effectiveness of physical activity programmes and services for older adults commissioned by the WHO. This commissioned work aimed to inform the development of an upcoming toolkit to assist countries to adopt, tailor and implement physical activity recommendations for older adults.

METHODS

Search strategy

Our systematic review with meta-analysis followed the methods described in the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.^{16 17} We performed this review in accordance with the methods documented in the protocol registered with the PROSPERO database prior to commencement (#CRD42021250901).

We conducted a systematic search of four electronic databases, including Medline (Ovid), Cumulative Index to Nursing and Allied Health Literature (CINAHL) (EBSCO), SPORT-Discus (EBSCO), the Physiotherapy Evidence Database (PEDro) for relevant English-language literature published from inception to April 2021. We used a combination of Medical Subject Heading terms and text words related to 'sport', 'older people', 'randomised' and 'controlled trial' to create our search strategy (see online supplemental appendix 1). In addition, included studies and reference lists of relevant reviews were hand searched.

Selection criteria

Study type

We included randomised controlled trials (RCTs) (see [box 1](#)).

Population

Trials involving adults aged 60+ years were eligible for inclusion. We also included trials where participants had an average or median age of at least 60 years. We included studies where participants were from the general population and studies where participants were recruited on the basis of having clinical conditions.

Intervention

We included any trial that examined the effects of any type of sport in older people. Sport was defined as 'an activity involving physical exertion, skill and/or hand-eye coordination as the primary focus of the activity, with elements of competition where rules and patterns of behaviour governing the activity exist formally through organisations'.¹⁸ We excluded studies

involving combined interventions (eg, supplement/nutrition and sports) unless the difference between groups was sport (eg, sport and nutrition vs nutrition). We also excluded video game-based sport interventions, rehabilitation and passive interventions.

We restricted our review to sport conducted in the community or clinical settings. We included trials that involved sport-based activities arranged through recreation clubs, sporting or non-sporting associations, gymnasiums or a wide variety of other sporting and non-sporting arrangements such as social clubs, church groups, retirement villages and seniors' associations. We excluded studies where the sport was conducted in participants' homes, residential care facilities, research laboratories or other non-community settings. Clinical settings were only included where there was a specific sports programme completed rather than routine rehabilitation programmes.

Comparator

To be eligible, trials had to compare one group that participated in sport with a non-active comparison group, such as usual care, waitlist or control group. We did not include trials that compared sport with another physical activity intervention.

Outcome measures

We previously developed a framework¹⁵ to classify physical activity intervention studies for older adults in terms of study sample, intervention characteristics, comparison group and outcomes investigated. We used this framework to guide inclusion of relevant health-related outcomes. As per our framework, outcome domains included physical activity, social functioning (participation), physical functioning, cognitive and emotional functioning, well-being and quality of life. We excluded any blood, metabolic or cardiovascular biomarkers (eg, inflammatory markers, neurotrophic biomarkers) and measures that are not routinely collected in clinical practice (eg, laboratory measures of cognitive function such as brain volume).

If we identified multiple publications from the same trial, we only included manuscripts that reported different outcomes. We excluded publications that included the same participants and reported the same outcomes as a previously included publication.

Study selection, data collection and extraction

Each title and abstract were independently screened by two out of three reviewers (SG, LM or LBM), and full texts of eligible studies were retrieved. Two out of three reviewers also assessed each retrieved full-text paper independently using the eligibility criteria. A third reviewer (JSO) resolved any conflicts. Titles, abstract and full-text studies were screened using Covidence systematic review software.¹⁹ Data extraction was conducted by one reviewer (SG or LBM), and all data were checked for consistency by a second reviewer (LBM) using standardised data extraction forms. We extracted the following data from each included trial: author, published year, country, sample characteristics (sample size, age and sex of participants, health status and recruitment setting), intervention description (type of sport, frequency, session duration, length of intervention, who delivered the intervention, where the intervention was delivered), comparison intervention, measured outcomes, follow-up and quantitative data for the meta-analysis.

Methodological quality assessment and quality of the evidence

We used the PEDro scale scores to assess the internal validity and methodological quality of the included RCTs.^{20 21} We downloaded

Box 1 Inclusion criteria

Design: Randomised controlled trials

Participants: Adults aged 60 years and over

Intervention: Any type of sport

Control: Non-active control intervention, no intervention, usual care

Outcomes measured related to: Physical activity, social functioning (participation), physical functioning, cognitive and emotional functioning, well-being and quality of life

Setting: Sport conducted in the community or clinical settings

PEDro scores from the PEDro database (<https://www.pedro.org.au/>). The PEDro scale consists of 11 items: inclusion criteria and source, random allocation, concealed allocation, similarity at baseline, subject blinding, therapist blinding, assessor blinding, completeness of follow-up, intention-to-treat analysis, between-group statistical comparisons, and point measures and variability. Scores on the PEDro scale range from 0 (very low methodological quality) to 10 (high methodological quality) although the highest possible score for a trial of a sport intervention is 8/10 as blinding of participants and deliverers is not possible. A score $\geq 6/10$ on the PEDro scale was considered moderate to high quality. Methodological quality was not an inclusion criterion for this review.

To assess the overall certainty of the evidence for outcomes with results from ≥ 3 studies, we used the Grading of Recommendations Assessment, Development and Evaluation system.²² We assigned a general rating of the certainty of the body of evidence as 'high', 'moderate', 'low', or 'very low' based on the presence or extent of four factors: design limitation, inconsistency, imprecision and publication bias. We downgraded from high quality by one level for the presence of each factor, as follows: (1) study limitation ($>25\%$ of participants from studies with low methodological quality: PEDro score <6), (2) inconsistency of results (large heterogeneity between trials: $I^2 > 60\%$), (3) imprecision (<400 participants across all studies) and (4) publication bias (serious small study effects suggested by the funnel plot). As the population, intervention, or outcomes did not differ from those in which we are interested, we do not have concerns about the indirectness criterion and did not downgrade for this criterion.

Data analysis

We used the random-effect model to pool estimates for each analysis obtained using Comprehensive Meta-analysis, V2.2.064 (Biostat, Englewood, New Jersey, USA). We calculated standardised mean difference (SMD) (Hedges' g) and 95% CI when the studies measured the same outcome but assessed it using different scales or tools. We standardised the SMD by postscore SD (or its estimate) and calculated it using the pre-mean and post-mean and SD or, when this was unavailable, the mean change score. If multiple follow-up data points were provided, the scores obtained as close to the completion of the intervention as possible were used for the analysis. Effect sizes were categorised as small (0.1 to 0.4), medium (0.5 to 0.7) or larger (0.8 or greater).²³ For the outcomes measured on the same scale, we calculated the mean difference (MD) (difference in means) and 95% CI to facilitate interpretation.

Statistical heterogeneity was determined by visual inspection of the forest plots and with consideration of the I^2 test. We considered substantial heterogeneity if $I^2 > 60\%$. We also investigated small study effects by using a funnel plot of the effect estimates from included studies. The funnel plot was assessed by visual inspection and by using Egger's test, with $p < 0.1$ as evidence of publication bias.²⁴

Differences between protocol and review

Minor changes in the planned review protocol occurred. As we had anticipated few trials on sport in older people would be available, we did not initially place any restrictions on the comparator in the protocol. However, we decided to focus this review on investigating the impact of sport on health outcomes, so we limited the comparator to non-active control.

RESULTS

The flow of trials through the review

After duplicates were removed, the electronic search retrieved 4267 references, and no additional studies were found by hand

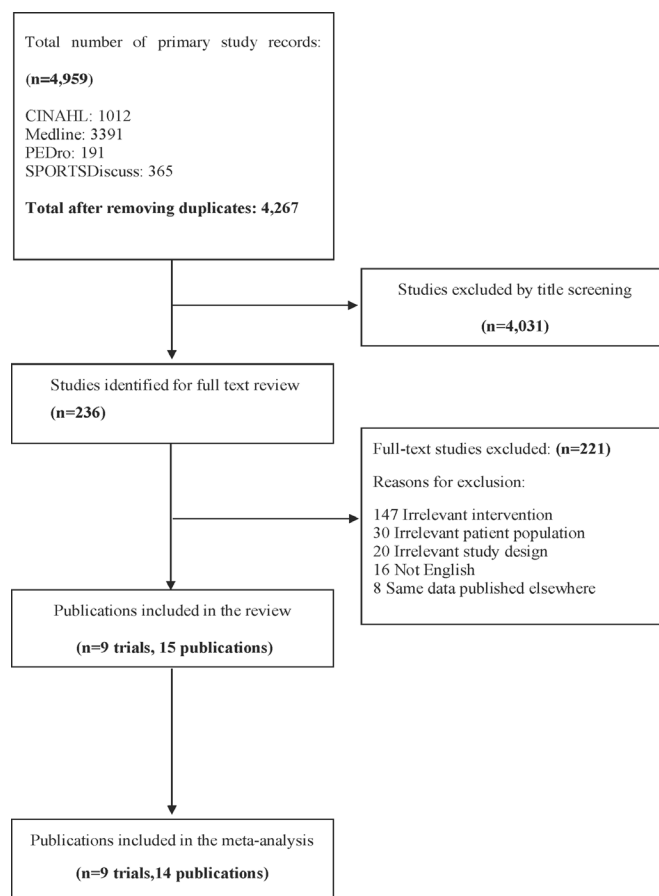


Figure 1 Flow of studies through the review.

search. After abstract and title screening of all references and full-text screening of 236 published papers, 15 publications^{25–39} reporting results of 9 RCTs met our inclusion criteria. We documented the screening process in a PRISMA study flow diagram (figure 1).

Characteristics of included trials

Publication dates ranged from 2014 to 2020 (median, 2017), with 60% of trials published after 2017. Most trials were conducted in high-income countries (8/9, 89% trials): Denmark (n=5/9 trials, 9 publications),^{25–27 29–31 36 37 39} Japan (n=1/9, 1 publication),³² Portugal (n=1/9, 1 publication),³¹ Faroe Islands (n=1/9 trials, 2 publications).^{33 34} One trial (2 publications)^{28 38} was conducted in an upper middle income country (ie, Brazil), and none of the studies were from low-/middle-income countries (LMIC).

We synthesised the details of the population, intervention, measured outcomes and follow-up in online supplemental table 1. For a single trial,³⁰ details of the intervention were summarised in online supplemental table 1, but the data were not included in any meta-analysis as this study only reported pooled sport intervention and resistance training results.

Quality

The online supplemental table 2 summarises the methodological quality of eligible studies. The total PEDro score ranged from 4 to 8, with a mean of 5. Four publications were of moderate-to-high methodological quality (PEDro score ≥ 6), and 11 publications were of low methodological quality (PEDro score < 6). All participants were randomly allocated, and all studies provided

between-group comparisons and the calculation of point estimates and variability. Intention-to-treat analysis was infrequently undertaken (4 studies; 33%). None of the trials included blinded participants or blinded therapists, as expected in sports interventions.

Participants

The nine trials involved a total sample of 628 participants ranging from 26 to 214 (median, 67 participants). All studies included older people with a mean age between 60 and 80 years (mean, 67 years). Three trials (seven publications)^{25–27 29 35–37} included men only, a single trial included women only (one publication),³¹ and all the other trials (five studies, seven publications)^{28 30 32–34 38 39} involved mixed-sex populations. Most studies selected participants based on participants' low physical activity level (7 studies, 12 publications),^{25 26 28–35 39} and none selected participants based on physical or cognitive impairment.

Participants were recruited from varied settings, including community, outpatient clinics, senior centres and a population register. The target population recruited in the trials was mainly the general population (four studies, seven publications).^{25 26 29 30 32 35 39} Three studies recruited participants with a specific clinical condition: two trials (three publications) recruited people with prostate cancer,^{27 36 37} and one trial (two publications) included people with type 2 diabetes.^{28 33 34 38} One trial (two publications) included participants with pre-diabetes^{30 31} and one trial (one publication) included post-menopause women.³¹

Intervention

The most commonly investigated sport type was soccer (5 trials, 11 publications),^{25–29 33–38} followed by floorball, a type of floor hockey played indoors (two trials, two publications),^{30 39} golf (one trial, one publication),³² and handball (one trial, one publication).³¹ The length of sport intervention in the included trials ranged from 12 weeks to 52 weeks, and the mean duration was 16 weeks. Intervention frequency ranged from one to three times per week, with each session ranging from 16 to 120 min. In trial reports that specified who delivered the intervention, sport sessions were delivered by local and professional coaches, research staff, and experienced instructors were involved in the intervention delivery. The intervention took place in the community, university and local clubs, but most trials did not specify the delivery location.

Comparator

The comparators of the included studies were the control group (ie, no active group, general health education, nutritional interventions) in 7 trials (12 publications),^{25 26 28–35 38 39} and usual care in 2 trials investigating clinical populations (3 publications).^{27 36 37}

Outcome measures

The most commonly investigated outcome was body composition (ie, lean body mass and fat mass) using dual-energy X-ray absorptiometry (DXA) (n=6 trials), followed by cardiorespiratory fitness measured by expired gas analysis (n=5), bone mineral density (BMD) measured by DXA (n=4), muscle strength using various measures, including isokinetic and hand-held dynamometer (n=4), physical function measured using sit-stand test or by the physical domain of the 12-Item Short Form Health Survey (SF-12) (n=4), physical activity measured by the International Physical Activity Questionnaire (n=2), balance assessed using force platform (n=2), mental health measured by

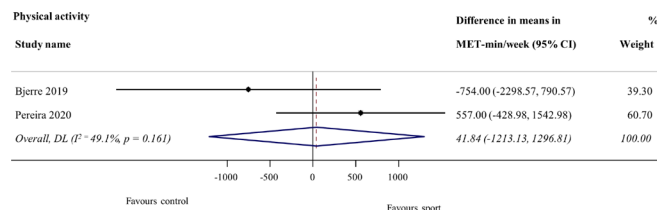


Figure 2 Difference in means (95% CI) of sport versus control on physical activity using random-effects meta-analysis.

Geriatric Depression Scale and mental health domain of SF-12 (n=2), and quality of life using the Functional Assessment of Cancer Therapy—Prostate (n=1).

Adverse events

Adverse events (AEs) were reported to some degree in all trials (online supplemental table 3). Six trials reported 90 AEs and three studies reported no AEs.^{28 32 34} Seventy-two out of 90 AEs were sports-related injuries, and the average incidence was 249 injuries per 1000 hours of exposure. The reported sport injuries included partial or total achilles' tendon rupture (reported in three trials), muscle sprain or strain (two trials), fibula subluxation (one trial) or fibula fracture (one trial), shoulder and knee injury (one trial). A single study²⁷ reported a serious adverse event (SAE) in both intervention and control groups (ie, hospital admissions), but only one was related to the intervention that occurred due to a scratch sustained from a shin guard that scratched the lower leg. This injury later became infected resulting in a skin transplant. Only one study reported falls in the control (6 falls) and intervention (10 falls) group, but this difference was not significant ($p=0.44$).²⁷

Meta-analysis

Meta-analyses for the included outcomes are presented in figures 2–5 and the certainty of the evidence summary is reported in online supplemental table 3. Social functioning (participation) was also not assessed by the trials.

Effect of sport on physical activity

We pooled two trials in the meta-analysis evaluating the effect of soccer and handball on overall physical activity levels (total pooled sample=244 participants). The pooled effect of sport on physical activity showed no effect compared with the control group (MD=41.84 MET-min/week, 95% CI -1213.13 MET-min/week to 1296.81 MET-min/week; $I^2=49\%$; figure 2). We

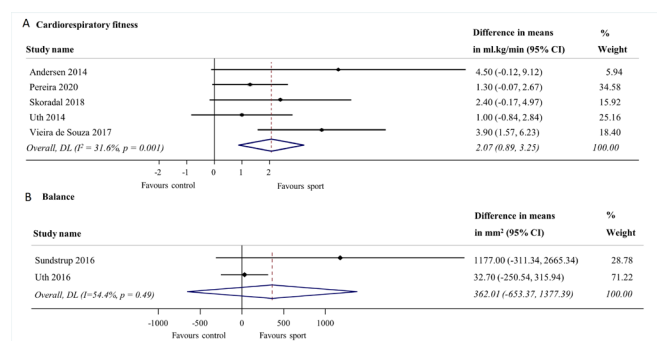


Figure 3 Difference in means (95% CI) of sport versus control on cardiorespiratory fitness and balance using random-effects meta-analysis.

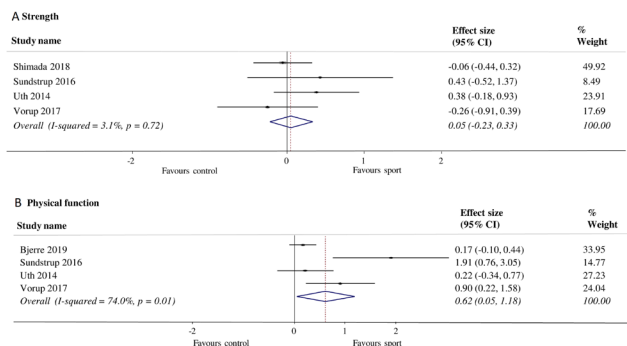


Figure 4 Standardised mean difference (Hedges' g) (95% CI) of sport versus control on strength and physical function using random-effect meta-analysis.

were unable to assess the certainty of evidence, as the meta-analysis results included <3 studies.

Effect of sport on physical functioning: cardiorespiratory fitness, balance, strength, physical function, body composition (fat mass and lean muscle mass) and BMD

Cardiorespiratory fitness

The meta-analysis showed a small significant effect of soccer and handball on cardiorespiratory fitness compared with control participants (5 studies, 224 participants; MD=2.07 mL.kg/min, 95% CI 0.89 mL.kg/min to 3.25 mL.kg/min; $I^2=32\%$; low certainty evidence; [figure 3](#)).

Balance

We found no significant impact of soccer on balance, assessed with force platform, compared with control (2 studies, 64 participants; MD=362.01 mm², 95% CI -653.37 mm² to 1377.39 mm²; $I^2=54\%$, [figure 3](#)). The overall quality of evidence for the effect of sport on balance was not assessed, as the meta-analysis results included <3 trials.

Strength

The meta-analysis showed no significant effect of soccer, golf and floorball in improving strength compared with control (4 studies, 312 participants; SMD=0.05, 95% CI -0.23 to 0.33; $I^2=3\%$; low certainty evidence; [figure 4](#)).

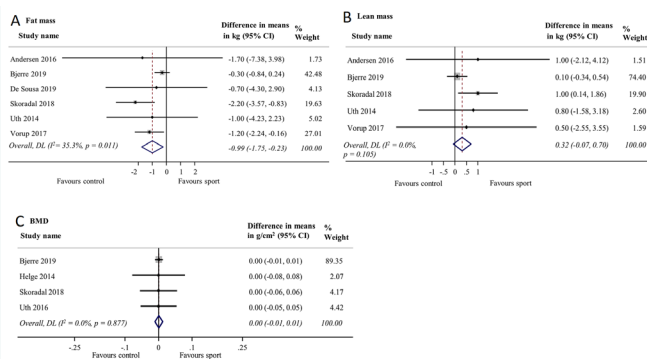


Figure 5 Difference in means (95% CI) of sport versus control body composition and bone mineral density (BMD) using random-effect meta-analysis.

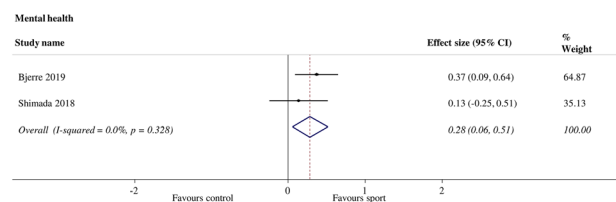


Figure 6 Standardised mean difference (Hedges' g) (95% CI) of sport versus control on mental health using random-effect meta-analysis.

Physical function

The pooled effect of soccer and floorball showed a medium significant effect on physical function in participants who undertook sport versus control participants (4 studies, 314 participants, SMD=0.62, 95% CI 0.05 to 1.18; $I^2=74\%$; very low certainty of evidence; [figure 4](#)).

Body composition

We detected a significant effect of soccer and floorball in reducing fat mass (6 studies, 361 participants; MD=-0.99, 95% CI -1.75 to -0.23; $I^2=35\%$; low certainty of evidence; [figure 3](#)) but not in improving lean mass (5 studies, 359 participants; MD=0.32 kg, 95% CI -0.07 kg to 0.70 kg; $I^2=0\%$; low certainty of evidence; [figure 5](#)) compared with control.

Bone mineral density

The meta-analysis showed no significant difference in the effect of soccer compared with control on BMD (4 studies, 317 participants; MD=0.00 g/cm², 95% CI -0.01 g/cm² to 0.01 g/cm²; $I^2=0\%$; very low certainty of evidence; [figure 5](#)).

Effect of sport on cognitive and emotional functioning: mental health

The pooled effect of sport indicates a small significant effect on mental health in participants allocated to soccer or golf versus control participants (2 studies, 306 participants, SMD=0.28; 95% CI 0.06 to 0.51; $I^2=0\%$; [figure 6](#)). We were unable to assess the overall certainty of the evidence for mental health, as its results are from <3 studies.

Effect of sport on well-being and quality of life

Only one trial reported the effects of sport on quality of life outcomes.²⁷ Overall, participants allocated to soccer intervention presented no significant differential effect in quality of life compared with control (1 study, 200 participants; MD +0.5 points, 95% CI -2.8 to 3.8; $p=0.76$).

Publication bias

Funnel plot symmetry was displayed and revealed no significant publication bias for all included outcomes, except BMD (see online supplemental figures 1 and 2).

DISCUSSION

Principal findings

This systematic review with meta-analysis demonstrated that sport may improve cardiorespiratory fitness, physical function and mental health, and reduce fat mass among older people. We are uncertain whether sport improves physical activity, strength, balance, lean mass, BMD and quality of life. No studies investigated social functioning as an outcome. Three trials reported no AEs, but most trials reported AEs and sport injuries (67% trials),

and the average incidence was 249 injuries per 1000 hours of exposure, which is high but expected for older population. However, the majority of the injuries were minor AEs and only one was SAE.

Interpretation of the findings

Our findings showed that sport participation was associated with significant cardiorespiratory fitness and physical function improvements. Similarly, a previous review⁴⁰ on small-sided soccer games indicated improvements in cardiorespiratory fitness and aerobic capacities assessed through maximum oxygen consumption ($\text{Vo}_{2\text{max}}$) in healthy individuals and clinical populations regardless of age. This review also demonstrated positive effects on physical function across the lifespan.⁴⁰ Our findings are also consistent with other related scoping reviews in untrained participants and clinical populations.^{41–43} The significant effects on cardiorespiratory fitness and physical function may reflect the physical requirements of the type of sports included in this review, which involved vigorous-intensity activities (ie, soccer 7 METs; handball: 12 METs and floorball (hockey): 8 METs).⁴⁴ These types of sport usually involve high-intensity movements in various directions and accelerations, imposing considerable demands on the cardiovascular system and requiring certain levels of mobility.

Our findings also showed a small significant effect of sport on mental health. However, another recent review without meta-analysis on the psychological impacts of sport in older people found inconsistent results for the relationship between depression, anxiety and stress and sport participation.⁴⁵ As only two studies^{27 32} reported mental health as an outcome, caution is recommended in interpreting our findings. Studies further exploring the impact of sport on mental health are needed.

The general positive effects of sport on fat mass are also in keeping with other related systematic reviews.^{40 42 43} The positive changes in body composition might be associated with increases in intensive energy expenditure during sport sessions. Another potential explanation is that the increase in energy expenditure also potentially increased lipid metabolism during training and post-training.²⁵

In contrast to other reviews,^{40–43} our study did not show a significant effect of sport on strength, balance, lean mass, BMD and quality of life. Improvements in these outcomes may be related to the type of training or dose of the intervention, but we were unable to draw firm conclusions due to the limited evidence and number of studies investigating these outcomes. Given the lack of impact on these outcomes, further studies should investigate the combination of sport and other types of training (ie, resistance, functional and/or balance training). Further studies are warranted to explore the impact of different forms of sport, the combination of sport and different types of exercise and to identify the optimal dose to maximise the benefits for these outcomes in older people.

Surprisingly, we did not find any impact of sport on overall physical activity levels in older participants. However, only two studies investigated physical activity outcomes.^{27 31} This finding may be explained by the fact that participants might have replaced their usual physical activity with sport. Another potential explanation is that some participants allocated to the sports group experienced AEs during the intervention, which has impacted sport participation and consequently might have decreased overall physical activity levels.

Strengths and limitations

This is the first systematic review with meta-analysis to summarise the impact of sport participation on health-related outcomes specifically in older people. Although some outcomes were not commonly

assessed across the studies, we performed a meta-analysis and summarised the pooled effect of sport for most of the included outcomes. We conducted this systematic review in accordance with the PRISMA recommendations and Cochrane Handbook guidelines and followed a protocol registered on PROSPERO. We used a comprehensive search strategy in four medical literature and topic-specific databases. We also included trials where participants were from the general population and with clinical conditions, contributing to a diverse sample.

We acknowledge some limitations of this review. Our results are limited to the short-term or immediate impacts of sport without considering the sustainability of effects, as we only analysed data from the closest post-intervention time-point. Due to the practical challenges in locating and assessing non-English studies, we only included trials published in English. Hence, we may have missed key data from studies in other languages and from LMIC, which may bias our review. We also included studies that involved healthy populations as well as participants with clinical conditions, which could introduce statistical heterogeneity. Due to the inclusion of a few studies in the meta-analysis, we were unable to explore the effect of participants' characteristics on the pooled effect size. Another limitation is that our review did not identify a wide range of sport types. Only four types of sport were explored in the included trials, and the trials predominantly investigated the impact of soccer (56% trials; 73% publications) on health-related outcomes. As such, conclusions may not be applicable to all forms of sport, such as combat or water sports. Additionally, we identified a limited number of studies investigating outcomes such as quality of life, balance and physical activity, and the interpretation of the impact of sport on these outcomes requires caution and warrants further investigation. Finally, the small number of studies included in our review shows a limited body of evidence in the area. In interpreting the review findings, it is important to note that we provided preliminary evidence, and further research is warranted to investigate the impact of sport on health-related outcomes among older people.

Implications for clinicians and policy-makers

Given the increasing ageing population worldwide and the expected age-associated decline in health, prevention of chronic conditions through an active lifestyle is a priority action area for governments. Therefore, it is crucial to investigate different ways to enable appropriate opportunities for older adults to undertake enjoyable physical activity as they age. One way to promote physical activity at the population level could be sports participation. Our results support promoting sports participation to improve physical and mental health among older people. Sports can be recommended to promote an active lifestyle in leisure time for both healthy older people and those with a wide range of clinical conditions. Sports organisations should prioritise older adults and create appropriate opportunities for those with or without physical limitations and clinical conditions who want to participate in sports. It is also important to draw attention to safe sport participation for older people. Different sports and different ways of commencing sports are likely to impact differently on AEs. Sport organisations should take into consideration appropriate injury prevention strategies when promoting sport participation among older people.

Unanswered questions

Our results identified evidence of the short-term effects of sport in improving health-related outcomes among older people. However, the long-term impact of this type of intervention is not clear. Studies that evaluate the long-term health benefits of sport in older people are needed. Our findings also indicate

the need for future research investigating the impact of sport participation in LMIC. Additionally, we only found nine trials investigating the effects of sport in older people, and most of the included trials involved soccer as a form of sport. Further RCTs are warranted to explore the impact of different forms of sport on health-related outcomes in older people. Our review also identified only a few studies of the effect of sport on physical activity, balance, quality of life and mental health, and none on social functioning among older people. More high-quality research targeting these outcomes are needed. The methodological quality of most studies assessed by the PEDro scores was moderate to low (ie, most trials did not include concealed allocation, blinded assessors and intention-to-treat analysis). A better understanding of the role of sport participation on older people's health outcomes will be enhanced by more methodologically rigorous future research using well-designed interventions. Finally, our results showed a relatively high rate of injuries related to sport, so further studies investigating ways to prevent sport-related injuries and improve safe sport participation for people aged 60+ are also warranted.

CONCLUSION

This systematic review with meta-analysis provides evidence that sport may offer a promise for improving cardiorespiratory fitness, physical function and mental health, and reducing fat mass among people aged 60 years and older. However, there was uncertain evidence regarding the impact of sport on strength, balance, lean mass, BMD and quality of life, so different types of training or dose may be required to impact these outcomes. Future research is needed to explore the benefits of sports in LMIC, over the long-term and sport-related AEs. More high-quality and well-designed studies targeting the impact of sport on physical activity, balance, quality of life, mental health, social functioning are needed. Further research should also investigate different forms of sports, the combination of sport and other types of exercise, and the optimal dose to maximise the impact of sport participation among older people. A high rate of injuries related to sport participation was identified, and ways to increase safe participation for older people should be further investigated. Due to the limited number of studies in the area,

future studies examining the impact on health-related outcomes in older people are also needed.

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What are the findings?

- ⇒ Being physically active across the life course is key to maintaining physical function, health and well-being in older age.
- ⇒ Sport could be an enjoyable physical activity option for older people. Many people aged 60+ now participate in traditional and newer modified versions of sport, such as walking football and walking basketball.
- ⇒ There is a clear need for studies investigating the impact of sport participation in older age.

How might it impact on clinical practice in the future?

- ⇒ Sport may offer significant promise for improving cardiorespiratory fitness, physical function, mental health and reducing fat mass among older people.
- ⇒ The impact of sport on other outcomes, including strength, balance, lean mass, bone mineral density and quality of life requires further investigation.

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Supplementary Appendix 1 Literature searches**Medline (ovid): 3391 records as at 20 April 2021**

1. Baseball/ or Basketball/ or Bicycling/ or Boxing/ or Football/ or Golf/ or Gymnastics/ or Hockey/ or exp Martial Arts/ or exp Racquet Sports/ or cricket sport/ or team sports/
2. Return to Sport/ or exp Running/ or Skating/ or exp Snow Sports/ or Soccer/ or exp Swimming/
3. Volleyball/ or exp Water Sports/ or Weight Lifting/ or Wrestling/
4. "Track and Field"/
5. (mountain bik* or sports or AFL or alpine ski* or archery or athletics or badminton or basketball or biathlon or biking or Boxing or canoe* or cricket or cross country ski* or curling).tw.
6. (cycling or diving or duathlon or equestrian or fencing or football or golf or gymnastics or Handball or hippotherapy or Hockey or horseback riding or horse riding or judo or kayak or kickboxing or lawn bowls or bowling).tw.
7. (marathon or netball or badminton or snowboard or triathlon or Polo or powerlifting or runn* or rowing or sailing or shooting or Skating or skiing or snowboard or soccer or sport*).tw.
8. (surfing or swimming or table tennis or taekwondo or Tae Kwon Do or tenpin bowling or Tennis or Trampolin* or triathlon or volleyball or volley).tw.
9. (australian football or baseball or fencing or racing or rugby or sport* or tennis or union or league).tw.
- 10. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9**
11. *Aged/ or *"Aged, 80 and over"/
12. exp Aged/ not Adolescent.mp.
13. (elderly or seniors or geriatric).tw.
14. (older adj (adult or people or person\$1)).tw.
- 15. 11 or 12 or 13 or 14**
16. Randomized Controlled Trials as Topic/
17. Random Allocation/
18. Controlled Clinical Trials as Topic/
19. Control Groups/
20. Double-Blind Method/
21. Single-Blind Method/
22. Placebos/
23. randomized controlled trial.pt.
24. controlled clinical trial.pt.
25. (random\$ or RCT or RCTs).tw.
26. (controlled adj5 (trial\$ or stud\$)).tw.
27. (clinical\$ adj5 trial\$).tw.
28. (randomi?ed adj5 trial).mp.
- 29. 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28**
30. exp Animals/ not Humans/
31. 29 not 30
- 32. 10 and 15 and 31**

CINAHL (ebSCO): 1012 records as at 20 April 2021

S1 (MH "Baseball" OR "Basketball" OR "Cycling" OR "Boxing" OR "Football" OR "Golf" OR "Gymnastics" OR "Hockey" OR "Martial Arts" OR "Racquet Sports+" OR "Sports Re-Entry" OR "Running+" OR "Skating+" OR "Winter Sports+" OR "Soccer" OR "Sports" OR "Swimming" OR "Track and Field" OR "Volleyball" OR "Aquatic Sports+" OR "Weight Lifting" OR "Wrestling" OR "Sports Participation" OR "Bowling" OR "Fencing" OR "Handball" OR "Race Walking" OR "Skiing+" OR "Team Sports+" OR "Triathlon")

S2 (TI "mountain bik*" OR "sports" OR AFL OR "alpine ski*" OR archery OR athletics OR badminton OR basketball OR biathlon OR biking OR Boxing OR canoe* OR cricket OR "cross#country ski*" OR curling OR cycling OR diving OR duathlon OR equestrian OR fencing OR football)

S3 (AB "mountain bik*" OR "sports" OR AFL OR "alpine ski*" OR archery OR athletics OR badminton OR basketball OR biathlon OR biking OR Boxing OR canoe* OR cricket OR "cross#country ski*" OR curling OR cycling OR diving OR duathlon OR equestrian OR fencing OR football)

S4 (TI golf OR gymnastics OR Handball OR hippotherapy OR Hockey OR "horseback riding" OR "horse riding" OR judo OR kayak OR kickboxing OR "lawn bowls" OR bowling OR marathon OR netball OR badminton OR snowboard OR Triathlon OR Polo OR powerlifting OR runn* OR rowing OR sailing)

S5 (AB golf OR gymnastics OR Handball OR hippotherapy OR Hockey OR "horseback riding" OR "horse riding" OR judo OR kayak OR kickboxing OR "lawn bowls" OR bowling OR marathon OR netball OR badminton OR snowboard OR Triathlon OR Polo OR powerlifting OR runn* OR rowing OR sailing)

S6 (TI shooting OR Skating OR skiing OR snowboard OR soccer OR sport* OR surfing OR swimming OR "table tennis" OR taekwondo OR "Tae Kwon Do" OR "tenpin bowling" OR Tennis OR Trampolin* OR triathlon OR volleyball OR volley)

S7 (AB shooting OR Skating OR skiing OR snowboard OR soccer OR sport* OR surfing OR swimming OR "table tennis" OR taekwondo OR "Tae Kwon Do" OR "tenpin bowling" OR Tennis OR Trampolin* OR triathlon OR volleyball OR volley)

S8 (TI "australian football" OR "baseball" OR " curling" OR "fencing" OR " racing" OR "rugby" OR " sport*" OR "winter sports" OR Wrestling)

S9 (AB "australian football" OR "baseball" OR " curling" OR "fencing" OR " racing" OR "rugby" OR " sport*" OR "winter sports" OR Wrestling)

S10 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9

S11 (MH "Randomized Controlled Trials") OR (MH "Clinical Trials+") OR "Randomized Controlled Trial"

S12 (MH "Aged+") OR (MH "Aged, 80 and Over")

S13 S10 AND S11 AN S12

SPORTDiscus (ebSCO): 365 records as at 20 April 2021

S1 DE "BASEBALL" OR DE "BASKETBALL" OR DE "CYCLING" OR DE "BOXING" OR DE "FOOTBALL" OR DE "GOLF" OR DE "GYMNASTICS" OR DE "HOCKEY" OR DE "MARTIAL Arts" OR DE "RACQUETBALL" OR DE "SPORT for all" OR DE "RUNNING" OR DE "SKATING" OR DE "WINTER sports" OR DE "SOCCER"

S2 DE " sports" OR DE "MOTORSOCCER" OR DE "RUGBALL" OR DE " bowling" OR DE " dance sport" OR DE " fencing" OR DE " hockey" OR DE "road racing" OR DE "rugby" OR DE " soccer" OR DE " sports competitions" OR DE " tennis" OR DE " track & field" OR DE " workouts"

S3 DE "SWIMMING" OR DE "VOLLEYBALL" OR DE "AQUATIC sports" OR DE "AQUATIC sports competitions" OR DE "CANOE polo" OR DE "CANOES & canoeing" OR DE "DIVING" OR DE "DRAGON boat racing" OR DE "FISHING" OR DE "KNEEBOARDING" OR DE "RAFTING (Sports)" OR DE "REGATTAS" OR DE "ROWING" OR DE "SAILBOAT racing" OR DE "SAILING" OR DE "SURFING" OR DE "WATER polo" OR DE "WATER skiing" OR DE "WHITEWATER kayaking" OR DE "WHITEWATER rafting"

S4 DE "WEIGHT lifting" OR DE "WEIGHT lifting competitions" OR DE "WRESTLING" OR DE "SPORTS participation" OR DE "BOWLING" OR DE "FENCING" OR DE "HANDBALL" OR DE "WALKING (Sports)" OR DE "SKIS & skiing" OR DE "TEAM sports" OR DE "TRIATHLON"

S5 TI (mountain bik* OR sports OR AFL OR alpine ski* OR archery OR athletics OR badminton OR basketball OR biathlon OR biking OR Boxing OR canoe* OR cricket OR cross#country ski* OR curling OR cycling OR diving OR duathlon OR equestrian OR fencing OR football)

S6 TI (golf OR gymnastics OR Handball OR hippotherapy OR Hockey OR horseback riding OR horse riding OR judo OR kayak OR kickboxing OR lawn bowls OR bowling OR marathon OR netball OR snowboard OR triathlon OR Polo OR powerlifting OR runn* OR rowing OR sailing)

S7 TI (shooting OR Skating OR skiing OR snowboard OR soccer OR sport* OR surfing OR swimming OR table tennis OR taekwondo OR Tae Kwon Do OR tenpin bowling OR Tennis OR Trampolin* OR triathlon OR volleyball OR volley)

S8 TI (aussie rules OR australian football OR baseball OR fencing OR racing OR rugby OR winter sports OR Wrestling)

S9 AB (mountain bik* OR sports OR AFL OR alpine ski* OR archery OR athletics OR badminton OR basketball OR biathlon OR biking OR Boxing OR canoe* OR cricket OR cross#country ski* OR curling OR cycling OR diving OR duathlon OR equestrian OR fencing OR football)

S10 AB (golf OR gymnastics OR Handball OR hippotherapy OR Hockey OR horseback riding OR horse riding OR judo OR kayak OR kickboxing OR lawn bowls OR bowling OR marathon OR netball OR snowboard OR triathlon OR Polo OR powerlifting OR runn* OR rowing OR sailing)

S11 AB (shooting OR Skating OR skiing OR snowboard OR soccer OR sport* OR surfing OR swimming OR table tennis OR taekwondo OR Tae Kwon Do OR tenpin bowling OR Tennis OR Trampolin* OR triathlon OR volleyball OR volley)

S12 AB (aussie rules OR australian football OR baseball OR fencing OR racing OR rugby OR winter sports OR Wrestling)

S13 **S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12**

S14 controlled trial OR clinical trial

S15 random*

S16 random sampling

S17 clinic* W5 trial*

S18 random allocation

S19 randomized OR randomised

S20 randomized controlled trials

S21 **S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20**

S22 Older person OR older people OR older adult*

S23 "elderly" or "senior"

S24 DE "OLDER people" OR DE "AGING" OR DE "GERIATRICS" OR DE "RETIREMENT"

S25 **S22 OR S23 OR S24**

S26 S13 AND S21 AND S25

PEDro: 191 records as at 20 April 2021

Sport (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 24

Skiing (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 3

archery (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

athletics (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

badminton (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

basketball (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 1

biathlon* (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

biking (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

cycling (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 54

boxing (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 7

canoe* (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 1

cricket (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

curling (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 1

Diving (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

duathlon* (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

equestrian (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

fencing (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

football (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 3

golf (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 3

gymnastics (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 16

handball (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 1

hockey (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

horseback riding (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 1

horse riding (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 3

judo (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

kayak (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 3

kickboxing (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

lawn bowls (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

marathon (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results:0

netball (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results:0

polo (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

power lifting (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 5

run* (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 39

rowing (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 3

sailing (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

shooting (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

skating (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

snowboard (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

soccer (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 3

surfing (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

swimming (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 14

table tennis (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 1

Taekwondo (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

Tae Kwon Do (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

tenpin bowling (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

tennis (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 2

trampoline (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 3

triathlon* (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

volleyball (AB TI) AND gerontology (Subdiscipline) AND Clinical trial (method)

Results: 0

Supplementary Table 1 Description of included trials

Author name (year) Country, World Bank classification	PEDro score Randomised/analysed	Participants (Setting, health status; n, age mean (SD), % female by group)	Intervention	Control	Outcomes	Follow up
Andersen et al. (2016) ^{a,b,c,d} Denmark, High income	7/10 27/26	Recruitment setting: Community Health status: Healthy old men Soccer training group: n=10 (randomised); 9 (analysed) Age: 68 (4.0) % female: 0% (100% male) B. Control group: n= 8 (randomised and analysed) Age: 67.4 (2.7) % female: 0% (100% male)	<p>The training consisted of small-sided games (three, four or five-a-side). For the first 12 weeks, each training session was initiated with a 15-min low-intensity warm-up, including stretching, and the training was organised as 3x15-min exercise periods with 2-min rest periods. From 13–52 weeks, the players perform an individual 5-min warm-up prior to the football training followed by 4x15-min exercise periods with 2-min rest periods.</p> <p>Type of sport: Soccer</p> <p>Duration of the intervention (weeks): 16^a, 52^{b,c,d}</p> <p>Frequency: 2 sessions/week for 16 weeks^a, and 3sessions/week for the following 36 weeks</p> <p>Session duration (min): 60</p> <p>Delivered by: Not specified</p> <p>Location: University</p>	No intervention	<p>Fitness^a measure by cycling test with breath-by-breath gas analysis (VO2 max)</p> <p>Body composition^b: whole body fat mass and lean mass were determined by whole body Dual energy X-ray absorptiometry (DXA) scanning.</p> <p>BMD^c: whole body measured by DXA.</p> <p>Strength^d assessed by an isokinetic dynamometer.</p> <p>Balance^d measured by a force platform.</p> <p>Functional function^d measured by a sit-to-stand test.</p>	16 weeks ^a 52 weeks ^{b,c}

Author name (year) Country, World Bank classification	PEDro score Randomised/analysed	Participants (Setting, health status; n, age mean (SD), % female by group)	Intervention	Control	Outcomes	Follow up
Bjerre et al (2019) Denmark, High income	8/10 214/214 (Intention to treat analysis)	<p>Recruitment setting: Danish urological departments.</p> <p>Health status: Men diagnosed with prostate cancer</p> <p>Recreational soccer: n= 109 (randomised and analysed) Age: 67.8 (6.2) % female: 0% (100% male)</p> <p>Usual care group: n= 105 (randomised and analysed) Age: 69 (6.2) % female: 0% (100% male)</p>	<p>A. The training consisted of a 20-minute warm-up based on the FIFA 11+ program, with modified exercises for the upper body, followed by a 20-minute period with drills and lastly a 20-minute period of match play.</p> <p>Type of sport: Soccer</p> <p>Duration of the intervention (weeks): 26</p> <p>Frequency: 2 sessions/week</p> <p>Session duration (min): 60</p> <p>Delivered by: Local soccer coaches</p> <p>Location: Local soccer club</p>	B. Usual care	<p>Self-reported physical activity assessed by International Physical Activity Questionnaire (IPAQ).</p> <p>Physical function assessed by the physical domain of the 12-Item Short Form Health Survey (SF-12).</p> <p>Body composition: Whole-body fat mass and lean body mass assessed by DXA.</p> <p>Bone mineral density (BMD): whole body BMD assessed by DXA.</p> <p>Mental health assessed by mental health domain of SF-12.</p> <p>Quality of life assessed by Functional Assessment of Cancer Therapy–Prostate (FACT-P) questionnaire.</p>	26 weeks

Author name (year) Country, World Bank classification	PEDro score Randomised/analysed	Participants (Setting, health status; n, age mean (SD), % female by group)	Intervention	Control	Outcomes	Follow up
De Sousa et al. (2019) ^{e,f} Brazil, Upper-Middle income	4/10 51/41	Recruitment setting: Community Health status: Type-2 diabetes Age (total sample): 61 (6) Soccer + nutrition group: n= 19 (analysed) Age: not specified % female: 47% Nutrition group: n= 22 (analysed) Age: not specified % female: 55%	Supervised recreational soccer training consisted of ordinary small-sided (3v3 to 7v7) plus nutritional intervention. Type of sport: Soccer Duration of the intervention (weeks): 12 Frequency: 3 sessions/week Session duration (min): 40 Delivered by: not specified Location: not specified	Nutritional intervention: nutritional counselling plus dietary plan	Body composition^e: body fat mass measured by DXA. Body composition^f: Whole-body fat mass assessed using total-body DXA scanning. Fitness^f measured by cycling test with breath-by-breath gas analysis (VO ₂ max).	12 weeks
Pedersen et al. (2016) Denmark, High income	4/10 72/44	Recruitment setting: Seniors centres Health status: healthy untrained participants Team sport training group: n= 25 (randomised); 13 (analysed) Age: 79 (7) % female: 69% Control group: n= 21 (randomised); 12 (analysed) Age: 81 (5) % female: 50%	The team training group consisted of small-sided floorball, “cone ball,” “hula goal”. All team sport games were played 3 vs 3 or 4 vs 4 inside on a plastic floor sized ≈10 × 10 m, and no physical contact was allowed. Type of sport: floorball Duration of the intervention (weeks): 12 Frequency: 2 sessions/week Session duration (min): 60 Delivered by: not specified Location: Seniors centres	Control group not specified	Physical activity[*] measured by accelerometer. Strength[*] assessed using maximal repetitions of bicep curls. Physical function[*] measured by time up and go. Quality of life[*] measured using SF-12 and the Danish version of the Older People’s Quality of Life questionnaire (OPQOL).	12 weeks

Author name (year) Country, World Bank classification	PEDro score Randomised/analysed	Participants (Setting, health status; n, age mean (SD), % female by group)	Intervention	Control	Outcomes	Follow up
Pereira et al. (2020) Portugal, High income	5/10 71/67	Recruitment setting: Community Health status: untrained postmenopausal women Age (total sample): 68 (6) Team handball group: n= 42 (randomised); 41 (analysed) Age: not specified % female: 100% Control group: n= 29 (randomised); 26 (analysed) Age: not specified % female: 100%	The training involved standardised warm-up (comprising running, coordination, strength, flexibility, and balance exercises) and three 15-min period of recreational team handball played as small-sided games (mainly 5v5 and 6v6) and performed on an indoor court. No hard tackles were allowed, and the balls used during the training sessions were light and made of a soft material to avoid injuries. Type of sport: Handball Duration of the intervention (weeks): 16 Frequency: 2 to 3 sessions/week Session duration (min): 60 minutes Delivered by: not specified Location: not specified	Control group not specified	Physical activity measured by IPAQ Fitness measured by cycling test with breath-by-breath gas analysis (VO ₂ peak).	16 weeks
Shimada et al. (2017) Japan, High income	6/10 106/106	Recruitment setting: Community Health status: Healthy	The golf training involved 10 min warm-up period and stretching exercises, followed by a half-round of golf (100 min) and a 10 min cool-down period.	Health education	Strength: grip strength assessed by hand-held dynamometer. Mental health measured by Geriatric Depression Scale (GDS).	24 weeks

Author name (year) Country, World Bank classification	PEDro score Randomised/analysed	Participants (Setting, health status; n, age mean (SD), % female by group)	Intervention	Control	Outcomes	Follow up
		<p><u>Golf training group:</u> n= 53 (randomised and analysed) Age: 70 (4) % female: 47%</p> <p><u>Control group:</u> n= 53 (randomised and analysed) Age: 70 (5) % female: 45%</p>	<p>Type of sport: Golf</p> <p>Duration of the intervention (weeks): 24</p> <p>Frequency: not specified</p> <p>Session duration (min): 90 to 120</p> <p>Delivered by: professional golfer and staff members</p> <p>Location: Local golf club</p>			
Skoradal et al. (2018) ^{g,h} Faroe Islands, High income	5/10 55/50	<p>Recruitment setting: population register</p> <p>Health status: prediabetes</p> <p>Age (total sample): 61 (9)</p> <p><u>Soccer training group:</u> n= 27 (analysed) Age: not specified % female: 52%</p> <p><u>Control group:</u> n= 23 (analysed) Age: not specified % female: 48%</p>	<p>All sessions were organised as small-sided games (4v4-6v6) and were preceded by a 10-minute warm-up period plus dietary advice.</p> <p>Type of sport: Soccer</p> <p>Duration of the intervention (weeks): 16</p> <p>Frequency: mean of 2 sessions weekly</p> <p>Session duration (min): 30 to 60</p> <p>Delivered by: not specified</p> <p>Location: not specified</p>	Dietary advice	<p>BMD^g: total body measured by DXA scanning.</p> <p>Body composition^h: body mass; body fat; fat mass; lean body mass; waist circumference (DXA)</p> <p>Fitness^h assessed by cycling test with breath-by-breath gas analysis (VO₂ max).</p>	16 weeks

Author name (year) Country, World Bank classification	PEDro score Randomised/analysed	Participants (Setting, health status; n, age mean (SD), % female by group)	Intervention	Control	Outcomes	Follow up
Uth et al. (2014) ^{1,j} Denmark, High income	5/10 57/49	Recruitment setting: Outpatient clinic Health status: Patients with prostate cancer undergoing androgen deprivation therapy Soccer training group: n= 29 (randomised) and 26 (analysed) Age: 67 (7) % female: 0% (100% male) Control group: n= 28 (randomised) and 23 (analysed) Age: 67 (5) % female: 0% (100% male)	The soccer training consisted of 15 min of warm-up exercises (running, dribbling, passing, shooting, balance, and muscle strength exercises) followed 5 to 7 a-side small-sided games. Type of sport: Soccer Duration of the intervention (weeks): 12 Frequency: 2 to 3 sessions/week Session duration (min): 45 to 60 Delivered by: experienced instructor Location: University	Usual care	Fitnessⁱ assessed by cycling test with breath-by-breath gas analysis (VO ₂ max). Body compositionⁱ: lean body mass and body fat mass were determined by DXA. Strengthⁱ measured by a knee-extensor resistance machine with the 1RM test. Physical functionⁱ assessed by sit to stand Balance^j measured by a force platform. BMD^j: total-body measured by DXA scanning..	12 weeks
Vorup et al. (2017) Denmark, High income	5/10 67/48	Recruitment setting: Community Health status: Healthy untrained older people Floorball group: n= 22 (randomised) and 18 (analysed) Age: 74 (6)	Customised and supervised small-sided floorball and 'cone ball' performed indoor on a wooden surface. During the first 4 weeks, participants performed 4x4 min separated by 4 min of rest, and this was progressively increased to 5x4 and 6x4 min in weeks 5 to 8 and 9 to 12, respectively.	No intervention	Strength measured by maximal thigh strength (MVC) test. Physical function measured by sit to stand test. Body composition: lean mass and fat mass assessed by DXA.	12 weeks

Author name (year) Country, World Bank classification	PEDro score Randomised/analysed	Participants (Setting, health status; n, age mean (SD), % female by group)	Intervention	Control	Outcomes	Follow up
		% female: 56% B. Control group: n= 22 (randomised) and 17 (analysed) Age: 72 (7) % female: 53%	Type of sport: floorball Duration of the intervention (weeks): 12 Frequency: 3 sessions/week Session duration (min): 16 to 24 Delivered by: not specified Location: not specified			
Same trials reporting different outcomes: ^a Andersen et al. 2014, ^b Andersen et al. 2016, ^c Helge et al. 2014, ^d Sundstrup et al. 2016, ^e De Sousa et al. 2019, ^f Vieira de Sousa et al. 2019, ^g Skoradal et al. 2018 (a), ^h Skoradal et al. 2018 (b), ⁱ Uth et al. 2014, ^j Uth et al. 2016. *Data for these outcomes were not included in the meta-analysis, as the authors only reported pooled sport intervention and resistance training results. DXA: Dual energy X-ray absorptiometry; IPAQ: International Physical Activity Questionnaire; SF-12: 12-Item Short Form Health Survey; BMD: bone mineral density; FACT-P: Functional Assessment of Cancer Therapy–Prostate; OPQOL: Older People’s Quality of Life questionnaire; GDS: Geriatric Depression Scale; MVC: maximal thigh strength.						

Supplementary Table 2 Methodological quality and reporting of eligible studies (n =8 trials, 15 publications)

Study	PEDro Scale Items ^a											PEDro Score (0 to 10)
	1 ^b	2	3	4	5	6	7	8	9	10	11	
Andersen et al. (2014)	Y	Y	N	Y	N	N	N	N	N	Y	Y	4
Andersen et al. (2016)	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Bjerre et al. (2019)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
De Sousa et al. (2019)	N	Y	N	Y	N	N	N	N	N	Y	Y	4
Helge et al. (2014)	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Perdersen et al. (2017)	Y	Y	N	Y	N	N	N	N	N	Y	Y	4
Pereira et al. (2020)	N	Y	N	Y	N	N	N	Y	N	Y	Y	5
Shimada et al. (2018)	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Skoradal et al. (2018) a	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Skoradal et al. (2018) b	N	Y	N	Y	N	N	N	Y	N	Y	Y	5
Sundstrup et al. (2016)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Uth et al. (2014)	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Uth et al. (2016)	Y	Y	N	Y	N	N	N	N	N	Y	Y	4
Vieira de Sousa et al. (2017)	N	Y	N	Y	N	N	N	Y	N	Y	Y	5
Vorup et al. (2017)	Y	Y	N	Y	N	N	N	N	Y	Y	Y	5

Y = yes, N = no.^a 1 = Eligibility criteria and source of participants, 2 = random allocation, 3 = concealed allocation, 4 = baseline comparability, 5 = blinded participants, 6 = blinded therapists, 7 = blinded assessors, 8 = adequate follow-up, 9 = intention-to-treat analysis, 10 = between-group comparisons, 11 = point estimates and variability. ^b Item 1 does not contribute to the total score.

Supplementary Table 3 Details of adverse events (AEs) and serious adverse events (SAEs)

Author name (year)	Number of adverse events (AEs)	Number of serious adverse events (AEs)	AEs related to sport participation (number and type of AEs)	Exposure (hours)
Andersen et al. (2016) ^{a,b,c,d}	1 intervention, NR control	0 intervention, NR control	N: 1 Type: Achilles tendon tear (n=1)	32
Bjerre et al (2019)	71 intervention, 13 control	13 intervention, 24 control	N: 60 Type: muscle strain or sprain (n=40); partial and full ruptured of Achilles tendon (n=2); minor injuries not specified (n=18)	52
De Sousa et al. (2019) ^{e,f}	0 intervention, NR control	NR intervention, NR control	N: 0	24
Pedersen et al. (2016)	10 intervention, NR control	NR intervention, NR control	N: 3 Type: not specified minor injuries or pain (n=3)	8
Pereira et al. (2020)	1 intervention, NR control	0 intervention, NR control	N: 1 Type: finger subluxation (n=1)	40
Shimada et al. (2017)	0 intervention, 0 control	0 intervention, 0 control	N: 0	42
Skoradal et al. (2018) ^{g,h}	0 intervention, NR control	0 intervention, NR control	N: 0	30
Uth et al. (2014) ^{i,j}	5 intervention, NR control	NR intervention, NR control	N: 5 Type: fibula fracture (n=1), partial ruptured of Achilles (n=2), ankle sprain (n=1), quadriceps muscle strain (n=1)	24.5
Vorup et al. (2017)	2 intervention, NR control	NR intervention, NR control	N: 2 Type: shoulder injury (n=1), knee injury (n=1)	8.8
Same trials reporting different outcomes: ^a Andersen et al. 2014, ^b Andersen et al. 2016, ^c Helge et al. 2014, ^d Sundstrup et al. 2016, ^e De Sousa et al. 2019, ^f Vieira de Sousa et al. 2019, ^g Skoradal et al. 2018 (a), ^h Skoradal et al. 2018 (b), ⁱ Uth et al. 2014, ^j Uth et al. 2016. NR: not reported; AEs: Adverse events; SAEs: Serious adverse events				

Supplementary Table 4 Summary of the quality of evidence and strength of recommendation (GRADE)^a

Quality Assessment				
Meta-analysis	Downgraded			Overall
	Study limitations ¹	Inconsistency ²	Imprecision ³	Publication bias ⁴
Cardiorespiratory fitness	↓		↓	Low
Physical function	↓	↓	↓	Very low
Strength	↓		↓	Low
Fat mass	↓		↓	Low
Lean mass	↓		↓	Low
Bone mineral density	↓		↓	↓ Very low

^aWe were unable to assess the certainty of the evidence for physical activity, balance, mental health and quality of life outcomes, as their results are from < 3 studies.

¹>25% of participants from studies with low methodologic quality: PEDro score <6

²Heterogeneity > 60%

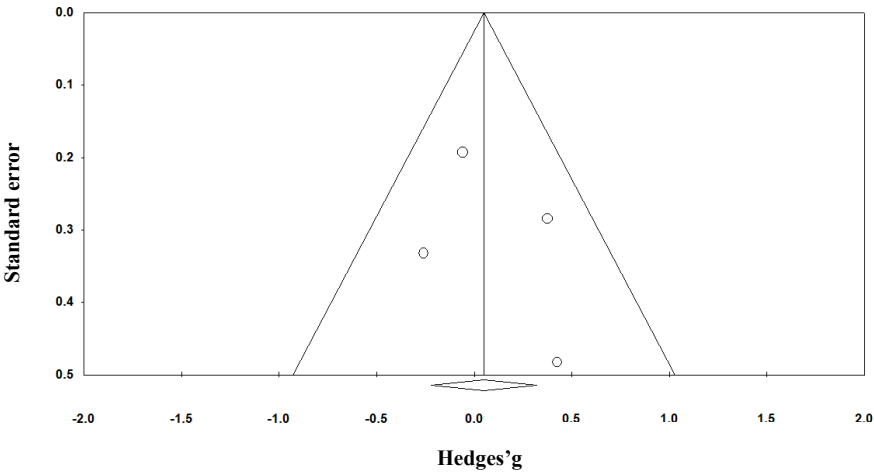
³<400 participants across all studies

⁴Serious small study effects suggested by funnel plot.

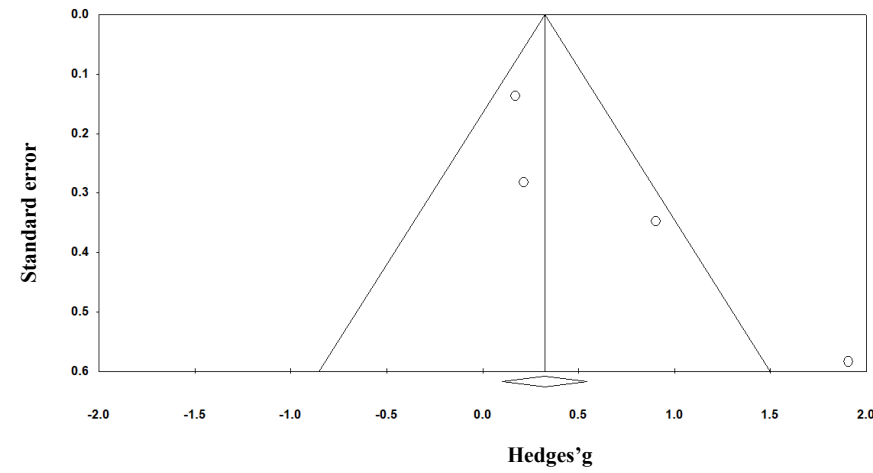
↓ Downgraded

Supplementary Figure 1 Funnel plot of standard error by Hedges’g for trials included in the meta-analysis for strength and physical function. Each circle represents one trial.

a) Strength (Egger’s test p-value= 0.59)



b) Physical function (Egger’s test p-value= 0.11)



Supplementary Figure 2 Funnel plot of standard error by difference in means for trials included in the meta-analysis for cardiorespiratory fitness, body composition and bone mineral density. Each circle represents one trial.

