Review Article

DIGITAL HEALTH

DIGITAL HEALTH
Volume 10: 1–18

DOI: 10.1177/20552076241239182
journals.sagepub.com/home/dhj
Sage

Comparative effectiveness of interventions on promoting physical activity in older adults: A systematic review and network meta-analysis

Shuang Wu[1], Guangkai Li[1], Beibei Shi[1], Hongli Ge[1], Si Chen[2], Xianliang Zhang[1] and Qiang He[1]

Abstract

Background: Despite the well-established health benefits of physical activity, a large population of older adults still maintain sedentary life style or physical inactivity. This network meta-analysis (NMA) aimed to compare the effectiveness of wearable activity tracker-based intervention (WAT), electronic and mobile health intervention (E&MH), structured exercise program intervention (SEP), financial incentive intervention (FI) on promoting physical activity and reducing sedentary time in older adults.

Methods: The systematic review based on PRISMA guidelines, a systematic literature search of PubMed, Web of Science, Google Scholar, EMbase, Cochrane Library, Scopus were searched from inception to December 10th 2022. The randomized controlled trials (RCT) were included. Two reviewers independently conducted study selection, data extraction, risk of bias and certainty of evidence assessment. The effect measures were standard mean differences (SMD) and 95% confidence interval (CI) in daily steps, moderate-to-vigorous physical activity (MVPA) and sedentary time.

Results: A total of 69 studies with 14,120 participants were included in the NMA. Among these included studies, the results of daily steps, MVPA and sedentary time was reported by 55, 25 and 15 studies, respectively. The NMA consistency model analysis suggested that the following interventions had the highest probability (surface under the cumulative ranking, SUCRA) of being the best when compared with control: FI + WAT for daily steps (SUCRA = 96.6%; SMD = 1.32, 95% CI:0.77, 1.86), WAT + E&MH + SEP for MVPA (SUCRA = 91.2%; SMD = 0.94, 95% CI: 0.36, 1.52) and WAT + E&MH + SEP for sedentary time (SUCRA = 80.3%; SMD = −0.50, 95% CI: −0.87, −0.14). The quality of the evidences of daily steps, MVPA and sedentary time was evaluated by very low, very low and low, respectively.

Conclusions: In this NMA, there's low quality evidence that financial incentive combined with wearable activity tracker is the most effective intervention for increasing daily steps of older adults, wearable activity tracker combined with electronic and mobile health and structured exercise program is the most effective intervention to help older adults to increase MVPA and reduce sedentary time.

Keywords

Wearable activity trackers, electronic and mobile health, financial incentives, physical activity, older adults, network meta-analysis

Submission date: 27 August 2023; Acceptance date: 27 February 2024

Introduction

With the increased aging of the global population, the physical and mental health of older adults has become a public health concern. Physical activity (PA) provides multiple health benefits for older population, including but not limited to reducing all-cause mortality, protecting against

[1]School of Physical Education, Shandong University, Jinan, China
[2]School of Nursing and Rehabilitation, Cheeloo College of Medicine, Shandong University, Jinan, China

Corresponding author:
Qiang He, School of Physical Education, Shandong University, Jinan 250061, China.
Email: hq@sdu.edu.cn

chronic diseases, improving mental health and cognitive function.[1,2] Several PA measures was closely associated with the health outcomes of old population. Firstly, walking is the most common PA and taking more steps is associated with a gradually declined risk of all-cause mortality with larger effects observed in older adults than in young adults.[3] Secondly, the intensity of PA is also an important determinator of health benefits. Compared with light intensity physical activity (LPA), moderate-to-vigorous physical activity (MVPA) and vigorous physical activity (VPA) can induce larger reduction of risk of mortality.[4] And 30–40 minutes MVPA per day can substantially attenuated the detrimental association between sedentary time and all-cause mortality.[5] MVPA was also associated with better aerobic fitness, larger strength in older adults.[6] Elderly people in higher MVPA quartile had lower risk of cognitive impairment.[7] The volume of PA is also important for health. A systematic review and meta-analysis demonstrated that individuals in the highest category of total physical activity (TPA) had 67% lower risk for mortality compared with individuals in the lowest category of TPA.[8] A higher level of TPA is also associated with a lower risk of diabetes,[9] cardiovascular disease,[10] and is positively associated with healthy aging.[11] On the contrary, low levels of PA and excess sedentary behavior (SB) are independently associated with multiple chronic diseases in older adults.[12] Physical inactivity was classified as the fourth leading cause of death worldwide while a global survey across 168 countries suggested that 27.5% people did not meet the PA recommendation.[13] Globally, 7.2% and 7.6% of all-cause and cardiovascular disease deaths, respectively, are attributable to physical inactivity.[14] SB is defined as any waking behavior in a seated or reclining posture, with a low energy expenditure (≤1.5 MET). Several longitudinal studies of older adults have demonstrated that greater total sedentary time was associated with various poor health outcomes among older adults, including all-cause mortality[15] and cardiovascular diseases.[16] Keadle et al.[17] found that older adults who watched 5 or more hours/day TV had a 28% higher risk of mortality over 6.6 years than those who watched TV less than 3 hours/day. Greater sedentary time is also associated with increased healthcare costs.[18] PA guidelines recommended older adults at least 150 minutes of moderate-intensity aerobic activity or 75 minutes of intense intensity aerobic activity every week, or an equivalent combination of the two, and the sedentary time should be limited.[19] However, older adults are one of the most sedentary groups, spending on average 80% of their time in a seated posture and with 67% being sedentary for more than 8.5 hours/day.[20] Therefore, addressing the global pandemic of physical inactivity and sedentary behavior should be a priority for public health agency. There's urgent need to identify and evaluate the efficacy of different types of available interventions to promote PA in older adults.

Interventions to promote PA and reduce sedentary behavior have been extensively developed and studied. Pairwise meta-analyses have been conducted to estimate the effectiveness of these interventions, and the outcomes were generally positive and promising in promoting PA,[21–24] and reducing sedentary time.[25] The overall effectiveness was modulated by population, settings (center, home), the use of theory or not, how interventions were delivered (face-to-face or remote, group-based or individual), intervention component as cognitive (e.g. education, counseling) or behavioral (e.g. self-monitoring, goal setting). For example, theory-based interventions were generally more effective than non-theory-based interventions in promoting PA of older adults.[26] The delivery methods of intervention was always a focus of interest in the field of physical activity intervention in recent years. However, most of traditional interventions delivered by face-to-face were labor and resource intensive. In recent years, wearable activity trackers (WATs) have been proved an effective and promising method to promote PA.[26–29] WATs empower users to monitor their steps, physical activity level or sitting time, sleep duration which can help users to achieve goals such as staying fit and active, losing weight, health self-monitoring. However, its role in older adults was less explored. At the same time, the booming of mobile and wireless technology, or information and communication technology render electronic Health (eHealth) and mobile health (mHealth)-based intervention a useful tool for increasing PA. Electronic and mobile Health intervention technologies included modalities like smartphone applications, the web, text message, as well as social media.[30] In addition, if participants can get special rewards for participating in sports activities, they can exercise more actively. The financial incentives have also been proved effective in improving PA.[22] All in all, PA interventions are usually complex and consist of multiple components rather than a single component. However, these complex interventions are typically assessed in pairwise meta-analyses that included parallel RCTs by comparing an intervention arm to control groups or another intervention. This approach excludes RCTs that do not have a similar comparator. Consequently, a limitation of this approach is that researchers cannot determine the degree of each single component of the included interventions would better contribute to the overall effect. Network meta-analyses can estimate effects from both direct and indirect comparisons which enables researchers to rank interventions as comparably more effective. Therefore, in this study, we aimed to perform a systematic review and NMA to inform public health policy by comparing different types of intervention on PA promotion in older adults.

Methods

This review was conducted following the criteria of Preferred reporting Items for Systematic Reviews and

Meta-analysis for Network Meta-analyses (PRISMA-NMA).[31] (Supplementary Table S1) This study protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO, registration number CRD42022345657).

Search strategy

We searched Pubmed, Web of Science, Google Scholar, EMbase, Cochrane Library, Scopus, and other databases for literatures investigating different types of intervention in promoting physical activity in older adults (Supplementary Table S2). The search was restricted to studies written in English and studies published before December 10th 2022. Search strategies were developed relating to six primary concepts of the review: “wearable activity trackers”, “electronic and mobile health (electronic and mobile Health)”, “financial incentives”, “structured exercise”, “physical activity (including sedentary time)” and “older adults”. The search formula was combined with medical subject headings (Mesh) and free-text terms. Search strategies were adapted for each data base as necessary. For example, to identify studies that included the wearable activity tracker, we used search terms including: Wearable devices(Mesh), Activity tracker(Mesh), Wearable tracker and Wearable monitor and so on. In addition, forward and backward citation searches were conducted for screening studies possible meeting the inclusion criteria but not detected in the initial search.

Selection criteria

The detailed inclusion criteria were as follows: (a) the mean age of the total sample of participants should be aged ≥ 60 years old, (b) the study design was randomized controlled trials (RCTs) or cluster-RCTs, (c) the interventions targeting increasing physical activity measures were included when using at least one of the following intervention, wearable activity tracker-based interventions (WAT), including accelerometers, pedometers, fitness trackers, etc. Electronic and Mobile health-based intervention (E&MH), including text messages, email, web, smartphone, apps, etc. Financial incentives-based intervention (FI), including but not limited to cash rewards, deposit contracts, and vouchers that could be exchanged for goods, etc. Structured exercise program-based interventions (SEP), including exercise programs, physical activity programs based behavior change strategies, exercise prescriptions, etc. Combined interventions (a combination of two or more interventions listed above), (d) the compactor received no intervention, usual care, wait list, (e) the primary physical activity outcomes were one of the following outcomes as daily steps, MVPA (minutes/week) and sedentary time (minutes/day) by objective measures or self-reported measures.

Data extraction

The search results were screened following three steps: (a) removing duplicates, (b) a preliminary screen by titles and abstracts, and (c) full-text screening. A Microsoft excel data sheet was established to extract and organize data from the included studies. The extracted data included author, country or region, publication year, sample size, characteristics of participants (age, gender, health status), intervention characteristics (intervention duration, intervention method), primary outcome measures (daily steps, weekly MVPA time and daily sedentary time). Two reviewers (S.W. and H.G.) independently screened data extraction process and resolved disagreement in consultation with the third reviewer (Q.H.).

Risk of bias assessment

The risk of bias of the studies included in this network meta-analysis was evaluated through the Cochrane risk assessment tool.[32] It assessed five domains, namely adequate sequence generation, allocation concealment, in-complete outcome data, selective reporting, and other sources of bias. Two reviewers (G.L. and B.S.) independently assessed the risk of bias, and an expert group (X.Z. and S.C.) was consulted to resolve disagreements.

Certainty of the evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to assess the quality of the evidence. Two reviewers (S.W. and G.L.) independently conducted the assessment and resolved disagreement in consultation with the third reviewer (Q.H.). Five domains were used to assess the quality of evidence (publication bias, indirectness, imprecision, study limitations, and consistency of effect), and the quality of the evidence was graded into high, moderate, low, and very low.[33]

Data synthesis and statistical methods

When reported, the mean change and standard deviations were used which was performed according to methods outlined in the Cochrane Handbook.[32] The standardized mean difference (SMD) with 95% confidence intervals (95% CI) was calculated as the effect size. SMD values <0.2, $0.2 \leq 0.5$, $0.5 \leq 0.8$, and > 0.8 were categorized as trivial, small, moderate, and large effect sizes, respectively.[34] A random effect network meta-analysis was performed to calculate pooled estimates. Stata 17.0 software was used to draw network graphs to describe and present the geometry of different interventions, with nodes representing different interventions and edges representing head-on comparisons between interventions. Global and local tests were carried out for the presence of inconsistency, while allowing for heterogeneity. The global inconsistency test compares the fit and parsimony of consistency and inconsistency models.[35] The local inconsistency test evaluates the difference between direct and indirect estimates in all closed loops in the network. Node splitting was used to evaluate the inconsistency of the model. Furthermore, probability ranking for each intervention was carried out using surface under cumulative ranking curve (SUCRA) percentage values as one of the final predictions. SUCRAs range from 0% to 100% with larger SUCRAs indicated as more effective intervention. Comparison-adjusted funnel plots were used to assess potential publication bias.

A series of pairwise meta-analyses were conducted by the random effects model. Heterogeneity of between-study comparisons was assessed by the I^2 statistic and values of $I^2 <$ 25%, 25%–≤50%, 50%–≤75%, and >75% were defined as very low, low, moderate, and high degrees of heterogeneity, respectively.[36] $P = 0.1$ was considered significant in the I^2 statistic. Publication bias was examined by Egger's test.

To test the robustness of the results and examine potential moderator variables for the primary outcomes, subgroup analyses were performed according to variables including age (<70 years old vs. ≥70 years old), health status (healthy vs. with chronic conditions) and intervention time (short-term ≤12 weeks vs. long-term >12 weeks).

Results

Literature selection

A total of 23,728 potentially relevant studies were obtained by searching databases, and 12 supplementary studies were manually searched (Figure 1). First of all, 13872 duplicates were removed. After preliminary screening by reading the title and abstract of the studies, 9788 irrelevant studies were excluded. After reading the full text of the remaining

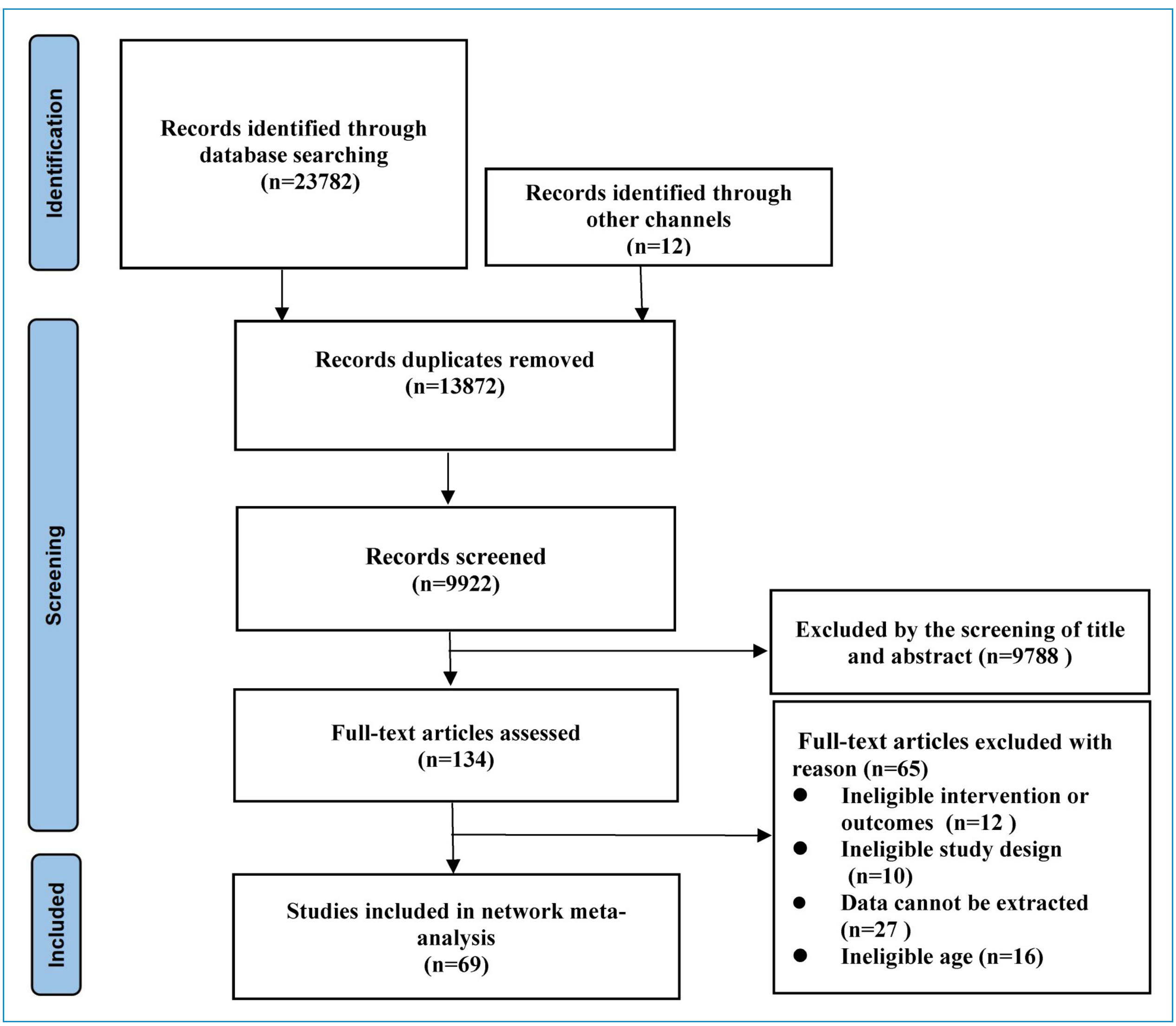

Figure 1. Flow chart of studies selection.

134 studies, 65 studies were excluded (27 studies did not report relevant data, 16 studies were ineligible in age, 10 studies were not RCT designed, and 12 studies did not meet the inclusion criteria). Finally, a total of 69 studies were included in this NMA.[37–105]

Characteristics of the included studies

A detailed summary of included studies (n = 69) is presented in Supplementary Table S3. A total of 14120 subjects were finally included and the sample size ranged from 15 to 1023. The mean age of included participants ranged from 60 to 83 years old. 33 studies included older adults with chronic conditions, and 11 studies included participants with chronic obstructive pulmonary diseases (COPD),[38,40,52,57,60,63,64,68,69,80,81] 8 studies included participants with type 2 diabetes (T2DM),[54,56,66,76,78,4–86] while the remaining 14 studies included participants with other chronic diseases.[50,55,58,59,62,74,87,91,95,97,98,102–104] The included studies assessed outcome variables using objective measurement and self reported. The objective measurement used two types of instruments: accelerometers or pedometers. The self reported of included studies was mainly used by international physical activity questionnaire (IPAQ).[37,49,90] The accelerometers from ActiGraph in the USA was most used by the included studies (n = 19).[42,45,55,59,62–64,72,74,76,77,80,83,86,100,102–105,]

A total of 55 studies reported a measure of daily steps,[39,40,42–44,46–48,50,52–71,73–79,81,83–87,91–100,102,103,105] 25 studies reported MVPA[41,42,45,46,51,55,58,63,64,72,74,76,77,80,84–86,88–91,100,103–105] and 15 studies reported sedentary time[37,38,48,49,59,64,71,72,76,82,86,89,100,102,105] The outcome variables of most included studies was mainly assessed by objective measurement. A total of four studies used self-reported to assessed physical activity, with one study only reported MVPA[90] and three studies only reported sedentary behavior.[37,49,82] The duration of the interventions ranged from 2 weeks to 12 months. 34 studies had an intervention duration less than 12 weeks,[39–41,43,46,48,49,52,53,58,59,61–64,71–74,77,79,82,84–86,89,92,94,95,100,105] while 35 studies used interventions longer than 12 weeks.[37,38,42,44,45,47,50,51,54–57,60,65,66,70,75,76,78,80,81,83,87,88,90,91,93,96–99,101–104]

Among the 69 studies included, there were 10 treatments. The interventions had main components included WAT (n = 19),[37,39,41,42,44,45,49,52,53,7781,87,93,9496,97,100,101,105] E&MH (n = 6),[65,80,86,90,91,93] SEP (n = 10),[38,40,47,50,55,60,61,75,82,98] FI (n = 5),[91–93,95,99] WAT + E&MH (n = 17),[39,41,42,48,51,53,54,56,62,63,68,69,74,77,79,87,104] WAT + SEP (n = 20),[38,40,43,46,50,57,60,61,64,66,67,70,71,73,75,76,81,84,85,101] FI + WAT (n = 3),[94,96,97] FI + E&MH (n = 3),[91,93,99] E&MH + SEP (n = 5)[72,78,88,102,103] and WAT + E&MH + SEP (n = 9).[47,57–59,72,79,83,89,103]

Quality assessment

The overall risk of bias of the included studies was presented in Figure 2 and Figure 3 while details were presented in (Supplementary Table S4). Overall, all studies reported a

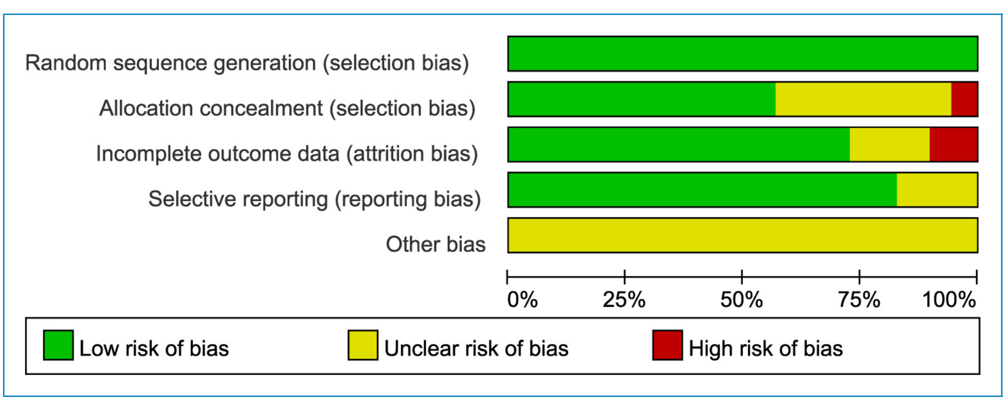

Figure 2. Risk of bias graph.

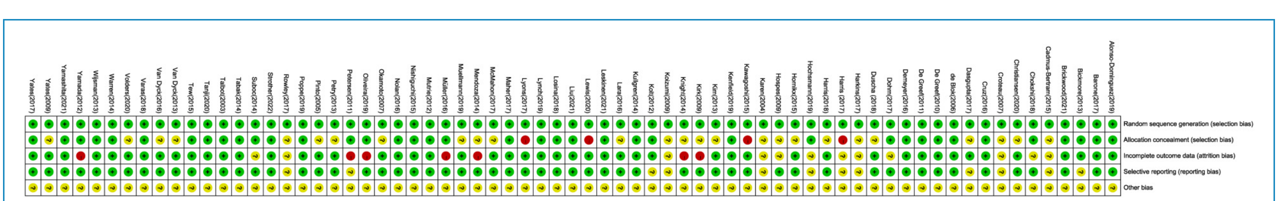

Figure 3. Risk of bias summary.

low risk of random sequence generation (100%). And 4 (5.6%) studies[38,41,48,100] were rated as high risk of bias in allocation concealment domain. Most studies were rated as low risk on incomplete outcome data while 7 (9.9%) studies[37,44,49,52,56,79,83] were rated as high risk of bias due to incomplete outcome data and remaining 12 (16.9%) studies[42,43,46,49,53,66,67,78,87,94,100,104] provided insufficient information in attrition bias. In addition, most studies were rated as low risk of bias on selective outcome reporting whereas 12 (16.9%) studies[42,43,46,49,53,66,67,78,87,94,100,104] provided insufficient information in reporting bias. Finally, all studies were classified as having an unclear risk of bias for other bias domains.

Certainty of evidence

The results of quality evaluation on three main physical activity measures by GRADE profiler software showed that the quality of evidence for daily step counts, MVPA was rated very low while the quality of the evidence for sedentary time was rated low. (Supplementary Table S5)

Network plots

The network plot of eligible comparisons on daily steps, MVPA, sedentary time are shown in Figure 4. The size of the nodes for each intervention indicates the number of studies included in the corresponding nodes. The thickness of the lines connecting 2 nodes indicates the amount of relevant data.

Daily steps

Fifty-five studies assessed daily steps and were eligible for NMA (Figure 4). The inconsistency model test did not show any significant difference for daily steps (p = 0.075)

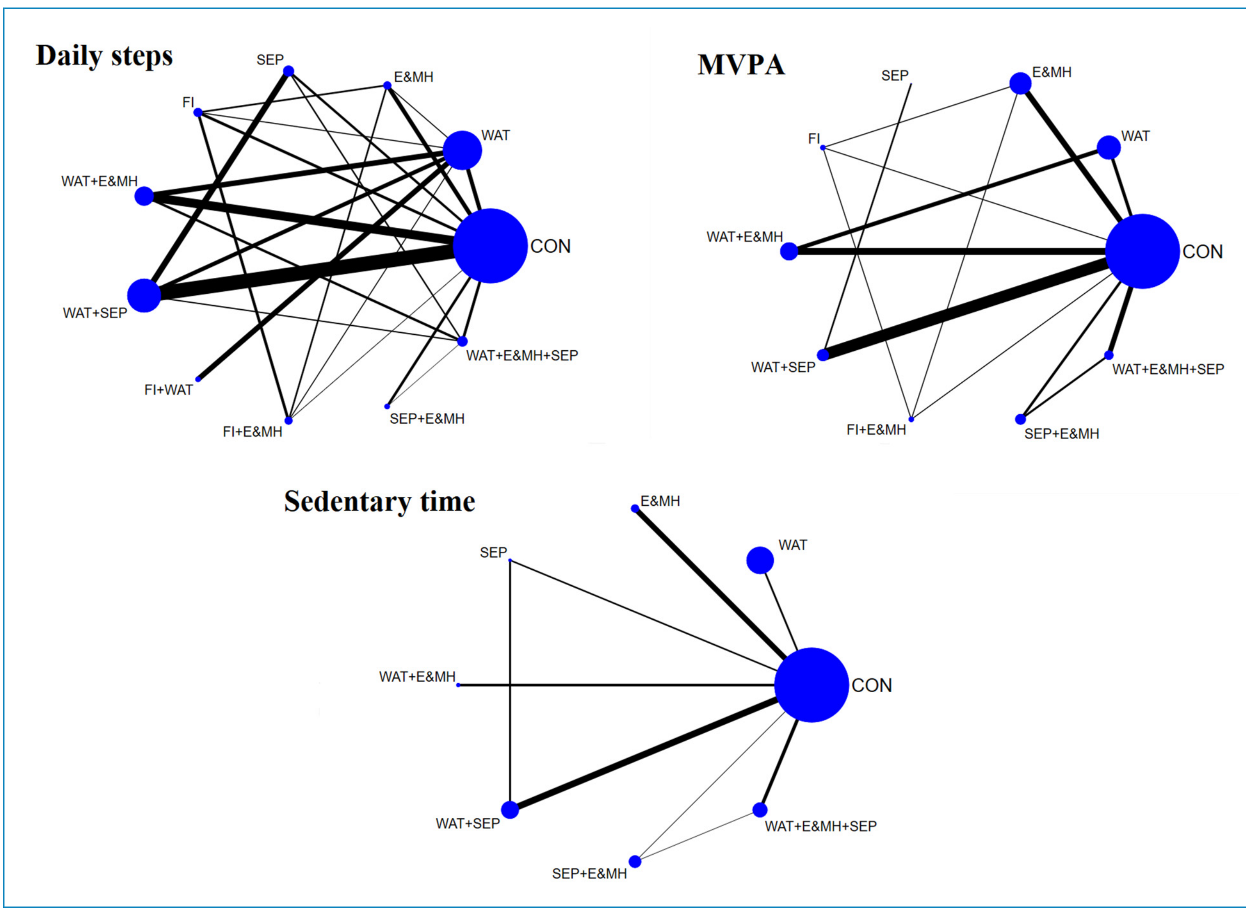

Figure 4. Network plots for studies examining the effectiveness of different interventions in older adults on daily steps, MVPA, sedentary time. CON: control; WAT: wearable activity tracker-based intervention, E&MH: electronic&mobile health intervention, SEP: structured exercise program intervention, FI: financial incentive intervention, WAT + E&MH: wearable activity tracker + electronic and mobile health intervention, WAT + SEP: wearable activity tracker + structured exercise program intervention, FI + WAT: financial incentive + wearable activity tracker intervention, FI + E&MH: financial incentive + electronic and mobile health intervention, E&MH + SEP: electronic and mobile health + structured exercise program intervention, WAT + E&MH + SEP: wearable activity tracker + electronic and mobile health + structured exercise program intervention.

(Supplementary Table S6). The consistency model analysis demonstrated that when compared with CON, interventions including WAT (SMD = 0.47, 95% CI: 0.21, 0.74, $P < 0.001$), SEP (SMD = 0.40, 95% CI: 0.03, 0.76, $P < 0.05$), WAT + E&MH (SMD = 0.74, 95% CI: 0.45, 1.03, $P < 0.001$), WAT + SEP (SMD = 0.44, 95% CI: 0.22, 0.66, $P < 0.001$), FI + WAT (SMD = 1.32, 95% CI: 0.77, 1.86, $P < 0.001$), E&MH + SEP (SMD = 1.04, 95% CI: 0.39, 1.67, $P < 0.001$), WAT + E&MH + SEP (SMD = 0.69, 95% CI: 0.31, 1.07, $P < 0.001$) can significantly increase the daily steps of older adults with small to large effect size (SMD = 0.40–1.3) except for the interventions including E&MH (SMD = 0.19, 95% CI: −0.21, 0.60, $P = 0.353$), FI (SMD = 0.34, 95% CI: −0.14, 0.82, $P = 0.179$) and FI + E&MH (SMD = 0.45, 95% CI: −0.13, 1.03, $P = 0.130$) (Supplementary Table S7). The local inconsistency test using the node splitting method showed that the direct and indirect comparisons between interventions were consistent ($P > 0.05$) (Supplementary Table S8). Table 1 presents NMA estimates of all interventions against all (SMD, 95% CI). The ranking probability of different interventions showed that the most effective intervention was FI + WAT (SUCRA = 96.6%) followed by SEP + E&MH (SUCRA = 86.3%), WAT + E&MH (SUCRA = 73.6%) and WAT + E&MH + SEP (SUCRA = 67.8%) while the least effective treatment was CON (SUCRA = 3.4%) (Supplementary Table S14 and Figure S4). No publication bias was detected evidenced by the funnel plot (Supplementary Figure S1). Pairwise meta-analysis for all comparisons are provided and considerable heterogeneity exist among most companions (min $I^2 = 0\%$, max $I^2 = 94.2\%$) (Supplementary Table S11). There was no significant difference between direct and indirect estimates in all closed loops (Supplementary Figure S7).

Subgroup analysis showed that compared with CON, six types of intervention (WAT, WAT + E&MH, WAT + SEP, FI + WAT, E&MH + SEP, WAT + E&MH + SEP) could significantly increase daily steps for relatively younger participants (<70 years) and FI + WAT is the best intervention (SUCRA = 93.9%). Although only three types of intervention (WAT, WAT + SEP, FI + WAT) could significantly increase daily steps in older participants (≥70 years), FI + WAT is still the best intervention (SUCRA = 98.0%). In addition, six types of intervention (WAT, SEP, WAT + E&MH, WAT + SEP, SEP + E&MH, WAT + E&MH + SEP) could significantly increase daily steps among participants with chronic conditions and FI + WAT is the best (SUCRA = 82.0%) while only four types of intervention (WAT, WAT + E&MH, WAT + SEP, FI + WAT) could effectively increase daily steps among healthy participants and FI + WAT is also the best intervention (SUCRA = 97.8%). Finally, five types of intervention (SEP, WAT + SEP, FI + WAT, SEP + E&MH, WAT + SEP + E&MH) could significantly increase daily steps in long-term with WAT + SEP + E&MH the best (SUCRA = 92.5%) while four types of intervention (WAT, WAT + E&MH, WAT + SEP, FI + WAT) was effective in short-term with FI + WAT the best (SUCRA = 94.9%) (Supplementary materials A–F).

MVPA

Twenty-five studies were eligible for the NMA of MVPA (Figure 4). The inconsistency model test did not show any significant difference for MVPA ($P = 0.16$) (Supplementary Table S6).The consistency model analysis results suggested that when compared with the CON, interventions including WAT + E&MH (SMD = 0.71, 95% CI: 0.37, 1.05, $P < 0.001$), WAT + SEP (SMD = 0.48, 95% CI: 0.10, 0.85, $P = 0.013$), WAT + E&MH + SEP (SMD = 0.94, 95% CI: 0.36, 1.52, $P = 0.002$) can significantly increase the weekly MVPA time of older adults (Supplementary Table S7). Table 2 presents the NMA estimates of all interventions against all (SMD, 95% CI). The ranking probability of different interventions showed that the most effective treatment was WAT + E&MH + SEP (SUCRA = 91.2%) followed by WAT + E&MH (SUCRA = 81.8%), WAT + SEP (SUCRA = 60.8%) and the least effective treatment was CON (SUCRA = 17.3%) (Supplementary Table S15 and Figure S5). No publication bias was detected evidenced by the funnel plot (Supplementary Figure S2). The local inconsistency test using the node splitting method showed that the direct and indirect comparisons between interventions were consistent ($P > 0.05$) (Supplementary Table S9). Pairwise meta-analysis for all comparisons are provided and considerable heterogeneity exist among most companions (min $I^2 = 0\%$, max $I^2 = 94.2\%$) (Supplementary Table S12). There was no significant difference between direct and indirect estimates in all closed loops (Supplementary Figure S8).

Subgroup analysis showed that compared with the CON, only two types of intervention (WAT + E&MH, WAT + E&MH + SEP) could significantly increase MVPA for relatively younger participants (<70 age) with WAT + E&MH + SEP the best (SUCRA = 97.6%). Only WAT + SEP could significantly increase MVPA in older participants (≥70 age). In addition, Only WAT + E&MH and WAT + SEP could significantly increase MVPA among participants with chronic conditions and WAT + SEP intervention is the best (SUCRA = 81.0%). Similarly, only two types of intervention (WAT + SEP, WAT + E&MH + SEP) could increase MVPA among those healthy participants and WAT + E&MH + SEP is the best (SUCRA = 86.4%). Finally, there are three types of intervention (WAT + E&MH, WAT + SEP, WAT + E&MH + SEP) that could significantly increase MVPA in short-term and WAT + E&MH + SEP is the best (SUCRA = 85.0%). And four types of intervention (WAT, WAT + E&MH, FI + E&MH, WAT + E&MH + SEP) was effective in long-term with WAT + E&MH + SEP the best (SUCRA = 94.4%) (Supplementary materials G-L).

Table 1. NMA comparisons of the effectiveness of different interventions on daily steps.

CON										
0.47 (0.22,0.74)	**WAT**									
0.19 (−0.21,0.60)	−0.28 (−0.74,0.19)	**E&MH**								
0.40 (0.03,0.76)	−0.07 (−0.50,0.36)	0.21 (−0.34,0.75)	**SEP**							
0.34 (−0.14,0.82)	−0.13 (−0.66,0.39)	0.15 (−0.40,0.69)	−0.06 (−0.66,0.54)	**FI**						
0.74 (0.45,1.03)	0.27 (−0.05,0.58)	**0.55 (0.06,1.04)**	0.34 (−0.11,0.79)	0.40 (−0.15,0.95)	**WAT + E&MH**					
0.44 (0.22,0.66)	−0.03 (−0.34,0.27)	0.25 (−0.21,0.71)	0.04 (−0.31,0.39)	0.10 (−0.43,0.63)	−0.30 (−0.65,0.05)	**WAT + SEP**				
1.32 (0.78,1.86)	**0.84 (0.37,1.32)**	**1.12 (0.46,1.79)**	**0.92 (0.27,1.56)**	**0.98 (0.27,1.69)**	**0.58 (0.00,1.15)**	**0.88 (0.31,1.45)**	**FI + WAT**			
0.45 (−0.13,1.03)	−0.02 (−0.63,0.59)	0.26 (−0.35,0.86)	0.05 (−0.63,0.74)	0.11 (−0.45,0.68)	−0.29 (−0.93,0.35)	0.01 (−0.64,0.63)	−0.87 (−1.64,−0.09)	**FI + E&MH**		
1.03 (0.39,1.67)	0.56 (−0.12,1.25)	**0.84 (0.08,1.60)**	0.62 (−0.08,1.35)	0.69 (−0.11,1.49)	0.29 (−0.40,0.98)	0.59 (−0.07,1.26)	−0.28 (−1.12,0.55)	0.58 (−0.28,1.45)	**E&MH + SEP**	
0.69 (0.32,1.06)	0.21 (−0.23,0.65)	0.59 (−0.05,1.05)	0.29 (−0.16,0.73)	0.35 (−0.26,0.96)	−0.05 (−0.49,0.38)	0.25 (−0.16,0.65)	−0.63 (−1.28,0.02)	0.24 (−0.46,0.93)	−0.35 (−1.00,0.31)	**WAT + E&MH + SEP**

CON = control, WAT = wearable activity tracker-based intervention, E&MH = electronic and mobile health intervention, SEP = structured exercise program intervention, FI = financial incentive intervention, WAT + E&MH = wearable activity tracker + electronic and mobile health intervention, WAT + SEP = wearable activity tracker + structured exercise program intervention, FI + WAT = financial incentive + wearable activity tracker intervention, E&MH + SEP = electronic and mobile health + structured exercise program intervention, FI + E&MH = financial incentive + electronic and mobile health intervention, WAT + E&MH + SEP = wearable activity tracker + electronic and mobile health + structured exercise program intervention.

Table 2. NMA comparisons of the effects of different interventions on MVPA.

CON									
0.37 (−0.00,0.74)	**WAT**								
0.27 (−0.13,0.67)	−0.10 (−0.64,0.45)	**E&MH**							
−0.73 (−1.91,0.45)	−1.10 (−2.33,0.14)	−1.00 (−2.24,0.25)	**SEP**						
0.17 (−0.69,1.04)	−0.20 (−1.14,0.74)	−0.10 (−0.96,0.76)	0.90 (−0.56,2.36)	**FI**					
0.71 (0.37,1.05)	0.34 (−0.09,0.77)	0.44 (−0.08,0.96)	**1.44 (0.21,2.67)**	0.54 (−0.39,1.47)	**WAT + E&MH**				
0.48 (0.10,0.85)	0.11 (−0.42,0.64)	0.21 (−0.34,0.75)	**1.20 (0.08,2.32)**	0.30 (−0.64,1.24)	−0.24 (−0.74,0.27)	**WAT + SEP**			
0.52 (−0.34,1.38)	0.15 (−0.79,1.09)	0.25 (−0.61,1.11)	1.25 (−0.21,2.71)	0.35 (−0.62,1.32)	−0.19 (−1.12,0.74)	0.05 (−0.90,0.99)	**FI + E&MH**		
0.38 (−0.13,0.90)	0.02 (−0.62,0.65)	0.11 (−0.53,0.76)	1.11 (−0.18,2.40)	0.21 (−0.79,1.21)	−0.33 (−0.94,0.29)	−0.09 (−0.73,0.54)	−0.14 (−1.14,0.87)	**E&MH + SEP**	
0.94 (0.36,1.52)	0.57 (−0.12,1.26)	0.67 (−0.03,1.37)	**1.66 (0.35,2.98)**	0.77 (−0.27,1.81)	0.23 (−0.44,0.90)	0.46 (−0.23,1.15)	0.42 (−0.62,1.46)	0.55 (−0.04,1.15)	**WAT + E&MH + SEP**

CON = control, WAT = wearable activity tracker-based intervention, E&MH = electronic and mobile health intervention, SEP = structured exercise program intervention, FI = financial incentive intervention, WAT + E&MH = wearable activity tracker + electronic and mobile health intervention, WAT + SEP = wearable activity tracker + structured exercise program intervention, FI + E&MH = financial incentive + electronic and mobile health intervention, E&MH + SEP = electronic and mobile health + structured exercise program intervention, WAT + E&MH + SEP = wearable activity tracker + electronic and mobile health + structured exercise program intervention.

Sedentary time

Fifteen studies assessed sedentary time and were eligible for the NMA (Figure 4). The inconsistency model test did not show any significant difference for sedentary time ($P =$ 0.102) (Supplementary Table S6).The consistency model analysis results demonstrated that compared with the CON, only WAT + SEP intervention (SMD = −0.43, 95% CI: −0.76, −0.09, $P = 0.012$) and WAT + E&MH + SEP intervention (SMD = −0.50, 95% CI: −0.86, −0.14, $P =$ 0.007) could significantly reduce daily sedentary time of older adults (Supplementary Table S7). Table 3 presents the NMA estimates of all interventions against all (SMD, 95% CI). The ranking probability of different interventions showed that the most effective treatment was WAT + E&MH + SEP (SUCRA = 80.3%) followed by WAT + SEP (SUCRA = 71.4%) while the least effective treatment was CON (SUCRA = 12.4%) (Supplementary Table S16 and Figure S6). The local inconsistency test using the node splitting method showed that the direct and indirect comparisons between interventions were consistent ($P >$ 0.05) (Supplementary Table S10). Pairwise meta-analysis for all comparisons are provided and considerable heterogeneity exist among most comparisons (min $I^2 = 0\%$, max $I^2 = 79.8\%$) (Supplementary Table S13). There was no significant difference between direct and indirect estimates in all closed loops (Supplementary Table S10). No publication bias was detected evidenced by the funnel plot (Supplementary Figure S3).

Subgroup analysis showed that compared with the CON, only the WAT + E&MH + SEP (SUCRA = 98.3%) could significantly reduce sedentary time for relatively younger participants (<70 age) while four types of intervention (SEP, WAT + SEP, E&MH + SEP, WAT + E&MH + SEP) could significantly reduce sedentary time in older participants (≥70 age) with WAT + SEP the best (SUCRA = 97.6%). In addition, it was suggested that no intervention could effectively reduce sedentary time among participants with chronic conditions while four types of intervention (SEP, WAT + SEP, WAT + E&MH + SEP, E&MH + SEP) could effectively reduce sedentary time among healthy participants and WAT + SEP is the best intervention (SUCRA = 92.3%). Finally, four types of intervention (SEP, WAT + SEP, E&MH + SEP, WAT + E&MH + SEP) could significantly reduce sedentary time in short-term and WAT + SEP still is the best (SUCRA = 81.9%). However, no intervention could effectively reduce sedentary time in long term (Supplementary Materials M-R).

Discussion

Main findings

The present NMA was the first study to demonstrate the efficacy of different interventions for promoting physical activity and reducing sedentary time in older adults. We found that financial incentive combined with wearable-activity trackers (for daily steps), wearable activity tracker combined with electronic and mobile health and structured exercise program (for MVPA and sedentary time) were likely the most effective interventions. Control including no intervention, usual care or wait list was the least effective intervention for all outcomes. However, the quality of the evidence ranged from very low to low according to the GRADE criteria which lead to limitations on these findings.

Improving daily steps

While physical activity guidelines from around the world are typically expressed in terms of frequency, duration and intensity parameters, step is an easily interpret-able, track-able measure of physical activity, and have been embraced by clinicians and consumers as a meaningful metric for physical activity promotion. And early studies suggested that the common reasons for older people to avoid performing physical activities are inconvenience and a lack of access to physical activity programs.[106] Walking is the most commonly targeted physical activity for older adults that can be practiced anywhere, so there are no problems involved with gaining access to programs. In addition, walking at 2.5 km/h (0.69 m/s) is sufficient for older adults to achieve the intensity of MVPA.[107] Accumulation of more daily steps provides multiple health benefits, including lower risk of mortality, cardiovascular events, hypertension, diabetes and obesity.[108–110] Although pairwise meta-analyses have suggested that wearable activity trackers,[28,111,112] financial incentives,[22,113] electronic and mobile-health[114,115] based physical activity interventions are effective in promoting daily steps, these reviews incorporated studies that used wearable activity trackers or financial incentives, electronic and mobile health as main or one of the components of intervention and cannot determine their contributions to the overall treatment effect. Our results demonstrated that a single use of financial incentives, electronic and mobile health and a combination of financial inventive and electronic and mobile health cannot efficiently increase daily steps for older adults. And the present NMA for the first time provided evidence that financial incentive combined with wearable activity tracker was the best choice for increasing daily steps of older adults regardless their age and health status.

In fact, according to behavior economics, immediate incentive is useful in emphasizing a short-term physical activity benefit and motivate more people to be active. The impact of financial incentives-based intervention on daily steps was reviewed previously with a small but significant estimated effect size (SMD = 0.25) reported.[113] Another review further explored the specific role of cash reward and found that modest incentives (1.40 US$/day

Table 3. NMA comparisons of the effectiveness of different interventions on sedentary time.

CON							
−0.04 (−0.27,0.20)	**WAT**						
−0.19 (−0.53,0.15)	−0.16 (−0.57,0.26)	**E&MH**					
−0.39 (−0.99,0.22)	−0.35 (−1.00,0.30)	−0.20 (−0.89,0.50)	**SEP**				
−0.22 (−0.71,0.27)	−0.18 (−0.73,0.36)	−0.03 (−0.63,0.57)	0.17 (−0.61,0.95)	**WAT + E&MH**			
−0.43 (−0.76,−0.09)	−0.39 (−0.80,0.02)	−0.24 (−0.72,0.24)	−0.04 (−0.66,0.58)	−0.21 (−0.80,0.39)	**WAT + SEP**		
−0.41 (−0.88,0.06)	−0.38 (−0.90,0.15)	−0.22 (−0.80,0.36)	−0.03 (−0.79,0.74)	−0.20 (−0.88,0.49)	0.01 (−0.55,0.58)	**E&MH + SEP**	
−0.50 (−0.87, −0.14)	**−0.47 (−0.90, −0.03)**	−0.31 (−0.81,0.19)	−0.12 (−0.82,0.58)	−0.28 (−0.90,0.33)	−0.08 (−0.55,0.40)	−0.09 (−0.56,0.38)	**WAT + E&MH + SEP**

CON = control, WAT = wearable activity tracker-based intervention, E&MH = electronic and mobile health intervention, SEP = structured exercise program intervention, WAT + E&MH = wearable activity tracker + electronic and mobile health intervention, WAT + SEP = wearable activity tracker + structured exercise program intervention, E&MH + SEP = electronic and mobile health + structured exercise program intervention, WAT + E&MH + SEP = wearable activity tracker + electronic and mobile health + structured exercise program intervention.

on average) were associated with increased mean daily steps during the intervention period (MD = 607.1), and this effects remained during follow ups even after incentives were removed (MD = 513.8).[22] The advantage over other interventions by financial incentive can be explained that older adults have lower incomes and are more sensitive to physical activity incentives.[116] And this review also reported that the greatest subgroup differences were observed for studies using incentives combined with wearable trackers when compared with a combination of incentives and smartphones.[22] In addition, less active and older adults usually gained larger steps increase. Thus, financial incentive combined with wearable trackers can generate synergistic effect in increasing daily steps which is further supported by our findings (SMD = 0.73). Subgroup analysis suggested that financial incentive combined with wearable tracker is still the best intervention which was not influenced by age and health status of participants, and it seems better in short-term intervention. This can be explained that older adults' positive attitude toward wearable activity tracker use did not persist long, and step counts showed waning patterns through the 3-month study period.[117] The modulating role of intervention duration on the effects of financial inventive targeting daily steps was also explored and results suggested that effects of short intervention duration ranging from 12 to 23 weeks (MD = 789.1) seemed better than intervention duration over 23 weeks (MD = 670.7).[22] Overall, the results of this NMA further strengthened the combination of financial incentive and wearable activity trackers which can be used by public health agency to promote daily steps for the old populations all over the world.

Improving weekly MVPA

In recent years, the broad health benefits of MVPA have been reported by numerous studies,[4,5] while data from 122 countries showed nearly a third (31.1%) of adults globally are physical inactive that do not meet the public health guidelines which recommended at least 150 minutes MVPA or an equivalent combination achieving 600 metabolic equivalent (MET)-min per week.[118] Therefore, strategies designed to increased MVPA should be prioritized and scaled up urgently.

Similarly, previous pairwise meta-analyses have reviewed the effectiveness of wearable activity trackers,[28,111,112] electronic and mobile health[119,120] based intervention on MVPA in adults. One limitation of these pairwise meta-analyses is that they can only provide a comparison between true intervention and control rather than different interventions. Our study suggested that wearable activity tracker combined with electronic and mobile health and structured exercise program intervention has the highest probably of being the best for improving MVPA level for older adults. A small to medium effect size in favor of MVPA increase was also observed for wearable activity tracker combined with electronic and mobile health intervention (SMD = 0.74), wearable activity tracker combined with structured exercise program (SMD = 0.48), respectively. Traditionally, structured exercise program was prescribed as moderate intensity in form of continuous aerobic exercise and/or combined with muscle strengthening exercise or flexibility exercise for older adults.[121] Undoubtedly, this would be helpful for increasing MVPA. However, structured exercise program seemed not enough to induce significant increase of weekly MVPA as it was usually prescribed 2–3 times per week, and duration of approximately 60 minutes each time with 30–40 minutes valid practice time when warm-up and cool-down time was excluded. For example, older adults in a 12-week exercise program (functional task exercise or resistance strength exercise) showed no significant difference in changing the physical activity score at 3, 6, or 9 months.[122] This can also be supported by our study that under the consistency model analysis, single structured exercise program intervention cannot efficiently increase weekly MVPA compared with the control. However, when combined with wearable activity trackers and electronic and mobile health, structured exercise program could better promote MVPA for older adults. In fact, wearable activity trackers and electronic and mobile health intervention can provide feedback on physical activity, sedentary time, enabling users to conduct self-monitoring, goal setting, social support whenever and wherever, not limited by time and space.[123] And, wearable activity trackers or electronic and mobile health intervention can be easily integrated with behavioral change counseling and other interventions. In addition, current pairwise meta-analyses about the effectiveness of financial incentive targeting physical activity was restricted to steps,[22] total physical activity,[113] energy expenditure,[113] exercise adherence.[124] Due to limited available studies, only four studies explored the effectiveness of financial incentive on physical activity in older adults aged over 60.[91,93,94,96] In these four studies, only one study led by Losina et al.[91] reported changes of MVPA following 6 months of intervention that financial incentive and telephone health coaching had the highest mean increase of MVPA (~39 minutes) while financial incentive, telephone health coaching and attention control induced a slight increase of MVPA (~14 minutes, ~16 minutes, ~14 minutes, respectively. And this study was conducted in patients following total knee replacement due to serious knee osteoarthritis. Thus, more future studies should be designed to determine the effect of financial incentive alone or combined with other components on MVPA in healthy older adults. Overall, this study suggests that public health workers should work with old adults to identify a strategy suitable for their interest to increase their MVPA level.

Reducing sedentary time

Older adults are the most sedentary population, spend an average 9.4 hours/day being sedentary.[20] High sedentary time is associated with various poor health outcomes, including all-cause mortality, cardiovascular diseases mortality, cancer mortality, type 2 diabetes.[125–127] To date, there are no widely accepted guidelines quantifying a limit for sedentary time. The Canadian 24-hour movement guidelines recommend older adults restrict sedentary time to a maximum of 8 hours/day.[128] Thus, interventions to reduce total sedentary time could potentially enhance physical health and well-being of older adults. In addition to interventions specifically targeted sedentary behavior,[129,130] interventions aiming to increase physical activity also were analyzed for their effectiveness to reduce sedentary time in recent reviews. Brickwood et al.[28] and Li et al.[111] reviewed wearable activity trackers targeting sedentary behavior in adults aged over 18 and a non-significant or no reduction of sedentary time was found following intervention whether it was used as either the primary component of an intervention or as part of a broader physical activity intervention. Wu et al.[112] demonstrated a significant reduction of sedentary time when the population was strictly restricted to old adults, but the effect size was trivial (SMD = −0.1). However, wearable activity tracker-based intervention can significantly reduce sedentary time (MD = −35.46 minutes/day) of hospitalized adults.[131] This might be associated with high concern about their health in this specific population. Therefore, wearable activity tracker-based intervention has the potential to promote the reduction of sedentary time for older adults but with limited effects. Yerrakalva et al.[114] reviewed the effectiveness of mobile-health app intervention on sedentary time of older adults and reported a potential to decrease sedentary time (SMD = −0.49) in short term. However, the results did not achieve statistical significance, possibly because studies were under powered by small participant numbers. Stockwell et al.[132] reviewed digital behavior change interventions defined as devices and programs using digital technology to foster or support behavior change, which include but are not limited to websites, mobile phones, smartphone apps, wearable devices, video games, virtual and augment reality devices. This extended e-health intervention with broad definition significantly reduced the sedentary time (SMD = −0.45, MD = 58) in older adults (≥50 years). The effect of structured exercise program on sedentary time in older adults was not systematically reviewed yet. Only a few studies examined the role of structured exercise program/ supervised exercise program on reducing sedentary time in adults, and generally the sedentary time and PA level cannot be changed significantly. For example, a 16-week aerobic training did not change the sedentary time and PA level of inactive older women.[132] Limited by available studies, our study found that wearable activity tracker combined with structured exercise program, wearable activity tracker combined with electronic and mobile health and structured exercise program could significantly promote the reduction of daily sedentary time of older adults while a single wearable activity tracker, electronic and mobile health or structured exercise program intervention had no significant impact on sedentary time. Overall, this study suggests that a combination of wearable activity tracker and structured exercise program with or without electronic and mobile health has the potential to reduce total sedentary time of older adults. However, limited by available studies, this conclusion needs to be strengthened by more future studies.

Our study had the following strengths. First, our study is the first network meta-analysis to compare the effects of different types of interventions on physical activity and sedentary time of older adults despite some of these treatments having never been compared head-to-head in trials. Secondly, searches were not limited by publication date or language. Our research includes comprehensive physical activity results, including daily steps, MVPA, and sedentary time.

There were some limitations in this study. First, the small sample sizes and bias in the included trials limit our conclusions. Many of the investigated interventions were not connected to the network, which hampered assessing the comparative effectiveness of all available interventions. Secondly, most of included trials used combined interventions that cannot specifically subdivided for discussion, thus hard to determine the contribution of specific intervention to the overall effect. Finally, the quality of evidence for daily steps, MVPA and sedentary time was rated very low or low which limited the reliability of this study.

Conclusions

This study provided evidence that various interventions are effective and should be incorporated into physical activity intervention program due to their potential for increasing daily steps, MVPA and reducing sedentary time. Apparently, combined intervention had a better effect on all physical activity measures. Examination of specific kinds of intervention was limited by the number of studies available and variability in reporting. And the quality of evidence for daily steps, MVPA and sedentary time was very low or low which limited the reliability of this study. Collectively, our findings provide evidence that financial incentive combined with wearable activity tracker-based intervention may be an effective methods to help older adults to increase more daily steps while wearable activity tracker combined with electronic and mobile health and structured exercise program may be a more effective intervention for improving MVPA and reducing sedentary time.

Contributions: S.W. performed data curation, formal analysis, visualization, and writing the original draft preparation; G.L. did formal analysis, visualization, and writing-review and editing; B.S. and H.G did data curation and formal analysis; S.C. and X.Z. did methodology, writing-review and editing and supervision; Q.H. did conceptualization, writing-review and editing, project administration, and funding acquisition. All authors have read and agreed the version of the manuscript.

Declaration of conflicting interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding: The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Shandong Province Social Science Foundation (grant number 22CTYJ06).

Consent statement: According to the journal submission guidelines, patient consent statement was not necessary due to our study is a systematic review.

Guarantor: Q.H.

ORCID iD: Shuang Wu https://orcid.org/0000-0002-4151-0811

Supplemental material: Supplemental material for this article is available online.

References

1. Hupin D, Roche F, Gremeaux V, et al. Even a low-dose of moderate-to-vigorous physical activity reduces mortality by 22% in adults aged >/=60 years: a systematic review and meta-analysis. *Br J Sports Med* 2015; 49: 1262–1267.
2. Liu L, Shi Y, Li T, et al. Leisure time physical activity and cancer risk: evaluation of the WHO's recommendation based on 126 high-quality epidemiological studies. *Br J Sports Med* 2016; 50: 372–378.
3. Paluch AE, Bajpai S, Bassett DR, et al. Daily steps and all-cause mortality: a meta-analysis of 15 international cohorts. *Lancet Public Health* 2022; 7: e219–e228.
4. Ballin M, Nordstrom P, Niklasson J, et al. Associations of objectively measured physical activity and sedentary time with the risk of stroke, myocardial infarction or all-cause mortality in 70-year-old men and women: a prospective cohort study. *Sports Med* 2021; 51: 339–349.
5. Ekelund U, Tarp J, Fagerland MW, et al. Joint associations of accelero-meter measured physical activity and sedentary time with all-cause mortality: a harmonised meta-analysis in more than 44 000 middle-aged and older individuals. *Br J Sports Med* 2020; 54: 1499–1506.
6. McGregor DE, Carson V, Palarea-Albaladejo J, et al. Compositional analysis of the associations between 24-h movement behaviours and health indicators among adults and older adults from the Canadian Health Measure Survey. *Int J Environ Res Public Health* 2018; 15: 1179.

7. Zhu W, Wadley VG, Howard VJ, et al. Objectively measured physical activity and cognitive function in older adults. *Med Sci Sports Exerc* 2017; 49: 47–53.
8. Ramakrishnan R, He JR, Ponsonby AL, et al. Objectively measured physical activity and all cause mortality: a systematic review and meta-analysis. *Prev Med* 2021; 143: 106356.
9. Aune D, Norat T, Leitzmann M, et al. Physical activity and the risk of type 2 diabetes: a systematic review and dose–response meta-analysis. *Eur J Epidemiol* 2015; 30: 529–542.
10. Aune D, Schlesinger S, Leitzmann MF, et al. Physical activity and the risk of heart failure: a systematic review and dose–response meta-analysis of prospective studies. *Eur J Epidemiol* 2021; 36: 367–381.
11. Daskalopoulou C, Stubbs B, Kralj C, et al. Physical activity and healthy ageing: a systematic review and meta-analysis of longitudinal cohort studies. *Ageing Res Rev* 2017; 38: 6–17.
12. Wirth K, Klenk J, Brefka S, et al. Biomarkers associated with sedentary behaviour in older adults: a systematic review. *Ageing Res Rev* 2017; 35: 87–111.
13. Guthold R, Stevens GA, Riley LM, et al. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. *Lancet Glob Health* 2018; 6: e1077–e1086.
14. Lee IM, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet* 2012; 380: 219–229.
15. Li S, Lear SA, Rangarajan S, et al. Association of sitting time with mortality and cardiovascular events in high-income, middle-income, and low-income countries. *Jama Cardiol* 2022; 7: 796–807.
16. Bellettiere J, LaMonte MJ, Evenson KR, et al. Sedentary behavior and cardiovascular disease in older women: the objective physical activity and cardiovascular health (OPACH) study. *Circulation* 2019; 139: 1036–1046.
17. Keadle SK, Arem H, Moore SC, et al. Impact of changes in television viewing time and physical activity on longevity: a prospective cohort study. *Int J Behav Nutr Phys Act* 2015; 12: 56.
18. Rosenberg D, Cook A, Gell N, et al. Relationships between sitting time and health indicators, costs, and utilization in older adults. *Prev Med Rep* 2015; 2: 247–249.
19. van der Ploeg HP and Bull FC. Invest in physical activity to protect and promote health: the 2020 WHO guidelines on physical activity and sedentary behaviour. *Int J Behav Nutr Phys Act* 2020; 17: 45.
20. Harvey JA, Chastin SF and Skelton DA. Prevalence of sedentary behavior in older adults: a systematic review. *Int J Environ Res Public Health* 2013; 10: 6645–6661.
21. Sansano-Nadal O, Gine-Garriga M, Brach JS, et al. Exercise-based interventions to enhance long-term sustainability of physical activity in older adults: a systematic review and meta-analysis of randomized clinical trials. *Int J Environ Res Public Health* 2019; 16: 2527.
22. Mitchell MS, Orstad SL, Biswas A, et al. Financial incentives for physical activity in adults: systematic review and meta-analysis. *Br J Sports Med* 2020; 54(21): 1259–1268. DOI:10.1136/bjsports-2019-100633.
23. Grande GD, Oliveira CB, Morelhao PK, et al. Interventions promoting physical activity among older adults: a systematic review and meta-analysis. *Gerontologist* 2020; 60: 583–599.
24. O'Halloran PD, Blackstock F, Shields N, et al. Motivational interviewing to increase physical activity in people with chronic health conditions: a systematic review and meta-analysis. *Clin Rehabil* 2014; 28: 1159–1171.
25. Gardner B, Smith L, Lorencatto F, et al. How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. *Health Psychol Rev* 2016; 10: 89–112.
26. Chase JA. Interventions to increase physical activity among older adults: a meta-analysis. *Gerontologist* 2015; 55: 706–718.
27. Tang M, Moore K, McGavigan A, et al. Effectiveness of wearable trackers on physical activity in healthy adults: systematic review and meta-analysis of randomized controlled trials. *Jmir Mhealth Uhealth* 2020; 8: e15576.
28. Brickwood KJ, Watson G, O'Brien J, et al. Consumer-based wearable activity trackers increase physical activity participation: systematic review and meta-analysis. *Jmir Mhealth Uhealth* 2019; 7: e11819.
29. Ferguson T, Olds T, Curtis R, et al. Effectiveness of wearable activity trackers to increase physical activity and improve health: a systematic review of systematic reviews and meta-analyses. *Lancet Digit Health* 2022; 4: e615–e626.
30. Kracht CL, Hutchesson M, Ahmed M, et al. E-&mHealth interventions targeting nutrition, physical activity, sedentary behavior, and/or obesity among children: a scoping review of systematic reviews and meta-analyses. *Obes Rev* 2021; 22: e13331.
31. Hutton B, Salanti G, Caldwell DM, et al. The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: checklist and explanations. *Ann Intern Med* 2015; 162: 777–784.
32. Cumpston M, Li T, Page MJ, et al. Updated guidance for trusted systematic reviews: a new edition of the cochrane handbook for systematic reviews of interventions. *Cochrane Db Syst Rev* 2019; 10: ED000142.
33. Balshem H, Helfand M, Schunemann HJ, et al. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol* 2011; 64: 401–406.
34. Cohen J. A power primer. *Psychol Bull* 1992; 112: 155–159.
35. Chaimani A, Higgins JP, Mavridis D, et al. Graphical tools for network meta-analysis in STATA. *Plos One* 2013; 8: e76654.
36. Higgins JP, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. *Br Med J* 2003; 327: 557–560.
37. Muller AM, Khoo S and Morris T. Text messaging for exercise promotion in older adults from an upper-middle-income country: randomized controlled trial. *J Med Internet Res* 2016; 18: e5.
38. Kawagoshi A, Kiyokawa N, Sugawara K, et al. Effects of low-intensity exercise and home-based pulmonary rehabilitation with pedometer feedback on physical activity in elderly patients with chronic obstructive pulmonary disease. *Respir Med* 2015; 109: 364–371.

39. Kim BH and Glanz K. Text messaging to motivate walking in older African Americans: a randomized controlled trial. *Am J Prev Med* 2013; 44: 71–75.
40. de Blok BM, de Greef MH, Ten HN, et al. The effects of a lifestyle physical activity counseling program with feedback of a pedometer during pulmonary rehabilitation in patients with COPD: a pilot study. *Patient Educ Couns* 2006; 61: 48–55.
41. Lewis ZH, Ottenbacher KJ, Fisher SR, et al. Effect of electronic activity monitors and pedometers on health: results from the TAME health pilot randomized pragmatic trial. *Int J Environ Res Public Health* 2020; 17: 6800.
42. Cadmus-Bertram LA, Marcus BH, Patterson RE, et al. Randomized trial of a fitbit-based physical activity intervention for women. *Am J Prev Med* 2015; 49: 414–418.
43. Karen AC, Nancy ER, Susan WV, et al. Effects of a pedometer-based physical activity program on older adults' mobility-related self-efficacy and physical performance. *Activities, Adaptation & Aging* 2004; 28: 19–33.
44. Yamada M, Mori S, Nishiguchi S, et al. Pedometer-based behavioral change program can improve dependency in sedentary older adults: a randomized controlled trial. *J Frailty Aging* 2012; 1: 39–44.
45. Leskinen T, Suorsa K, Tuominen M, et al. The effect of consumer-based activity tracker intervention on physical activity among recent retirees-an RCT study. *Med Sci Sports Exerc* 2021; 53: 1756–1765.
46. Koizumi D, Rogers NL, Rogers ME, et al. Efficacy of an accelerometer-guided physical activity intervention in community-dwelling older women. *J Phys Act Health* 2009; 6: 467–474.
47. Brickwood KJ, Ahuja K, Watson G, et al. Effects of activity tracker use with health professional support or telephone counseling on maintenance of physical activity and health outcomes in older adults: randomized controlled trial. *Jmir Mhealth Uhealth* 2021; 9: e18686.
48. Lyons EJ, Swartz MC, Lewis ZH, et al. Feasibility and acceptability of a wearable technology physical activity intervention with telephone counseling for mid-aged and older adults: a randomized controlled pilot trial. *Jmir Mhealth Uhealth* 2017; 5: e28.
49. Petersen CB, Severin M, Hansen AW, et al. A population-based randomized controlled trial of the effect of combining a pedometer with an intervention toolkit on physical activity among individuals with low levels of physical activity or fitness. *Prev Med* 2012; 54: 125–130.
50. Talbot LA, Gaines JM, Huynh TN, et al. A home-based pedometer-driven walking program to increase physical activity in older adults with osteoarthritis of the knee: a preliminary study. *J Am Geriatr Soc* 2003; 51: 387–392.
51. Wijsman CA, Westendorp RG, Verhagen EA, et al. Effects of a web-based intervention on physical activity and metabolism in older adults: randomized controlled trial. *J Med Internet Res* 2013; 15: e233.
52. Mendoza L, Horta P, Espinoza J, et al. Pedometers to enhance physical activity in COPD: a randomised controlled trial. *Eur Respir J* 2015; 45: 347–354.
53. Rowley TW, Lenz EK, Swartz AM, et al. Efficacy of an individually tailored, internet-mediated physical activity intervention in older adults: a randomized controlled trial. *J Appl Gerontol* 2019; 38: 1011–1022.
54. Van Dyck D, De Greef K, Deforche B, et al. The relationship between changes in steps/day and health outcomes after a pedometer-based physical activity intervention with telephone support in type 2 diabetes patients. *Health Educ Res* 2013; 28: 539–545.
55. Liu J, Kwan R, Yin YH, et al. Enhancing the physical activity levels of frail older adults with a wearable activity tracker-based exercise intervention: a pilot cluster randomized controlled trial. *Int J Environ Res Public Health* 2021; 18: 10344.
56. Kirk A, Barnett J, Leese G, et al. A randomized trial investigating the 12-month changes in physical activity and health outcomes following a physical activity consultation delivered by a person or in written form in Type 2 diabetes: Time2Act. *Diabet Med* 2009; 26: 293–301.
57. Varas AB, Cordoba S, Rodriguez-Andonaegui I, et al. Effectiveness of a community-based exercise training programme to increase physical activity level in patients with chronic obstructive pulmonary disease: a randomized controlled trial. *Physiother Res Int* 2018; 23: e1740.
58. Duscha BD, Piner LW, Patel MP, et al. Effects of a 12-week mHealth program on peak VO2 and physical activity patterns after completing cardiac rehabilitation: a randomized controlled trial. *Am Heart J* 2018; 199: 105–114.
59. Lynch BM, Nguyen NH, Moore MM, et al. A randomized controlled trial of a wearable technology-based intervention for increasing moderate to vigorous physical activity and reducing sedentary behavior in breast cancer survivors: The ACTIVATE Trial. *Cancer-Am Cancer Soc* 2019; 125: 2846–2855.
60. Nolan CM, Maddocks M, Canavan JL, et al. Pedometer step count targets during pulmonary rehabilitation in chronic obstructive pulmonary disease. a randomized controlled trial. *Am J Respir Crit Care Med* 2017; 195: 1344–1352.
61. Warren FC, Stych K, Thorogood M, et al. Evaluation of different recruitment and randomisation methods in a trial of general practitioner-led interventions to increase physical activity: a randomised controlled feasibility study with factorial design. *Trials* 2014; 15: 134.
62. Tew GA, Humphreys L, Crank H, et al. The development and pilot randomised controlled trial of a group education programme for promoting walking in people with intermittent claudication. *Vasc Med* 2015; 20: 348–357.
63. Demeyer H, Louvaris Z, Frei A, et al. Physical activity is increased by a 12-week semiautomated telecoaching programme in patients with COPD: a multicentre randomised controlled trial. *Thorax* 2017; 72: 415–423.
64. Cruz J, Brooks D and Marques A. Walk2Bactive: a randomised controlled trial of a physical activity-focused behavioural intervention beyond pulmonary rehabilitation in chronic obstructive pulmonary disease. *Chron Respir Dis* 2016; 13: 57–66.
65. Lara J, O'Brien N, Godfrey A, et al. Pilot randomised controlled trial of a web-based intervention to promote healthy eating, physical activity and meaningful social connections compared with usual care control in people of retirement age recruited from workplaces. *Plos One* 2016; 11: e0159703.

66. Dasgupta K, Rosenberg E, Joseph L, et al. Physician step prescription and monitoring to improve ARTERial health (SMARTER): a randomized controlled trial in patients with type 2 diabetes and hypertension. *Diabetes Obes Metab* 2017; 19: 695–704.
67. Croteau KA, Richeson NE, Farmer BC, et al. Effect of a pedometer-based intervention on daily step counts of community-dwelling older adults. *Res Q Exerc Sport* 2007; 78: 401–406.
68. Hornikx M, Demeyer H, Camillo CA, et al. The effects of a physical activity counseling program after an exacerbation in patients with Chronic Obstructive Pulmonary Disease: a randomized controlled pilot study. *Bmc Pulm Med* 2015; 15: 136.
69. Tabak M, Vollenbroek-Hutten MM, van der Valk PD, et al. A telerehabilitation intervention for patients with Chronic Obstructive Pulmonary Disease: a randomized controlled pilot trial. *Clin Rehabil* 2014; 28: 582–591.
70. Okamoto N, Nakatani T, Morita N, et al. Home-based walking improves cardiopulmonary function and health-related QOL in community-dwelling adults. *Int J Sports Med* 2007; 28: 1040–1045.
71. Mutrie N, Doolin O, Fitzsimons CF, et al. Increasing older adults' walking through primary care: results of a pilot randomized controlled trial. *Fam Pract* 2012; 29: 633–642.
72. Muellmann S, Buck C, Voelcker-Rehage C, et al. Effects of two web-based interventions promoting physical activity among older adults compared to a delayed intervention control group in Northwestern Germany: results of the PROMOTE community-based intervention trial. *Prev Med Rep* 2019; 15: 100958.
73. Nishiguchi S, Yamada M, Tanigawa T, et al. A 12-week physical and cognitive exercise program can improve cognitive function and neural efficiency in community-dwelling older adults: a randomized controlled trial. *J Am Geriatr Soc* 2015; 63: 1355–1363.
74. Kenfield SA, Van Blarigan EL, Ameli N, et al. Feasibility, acceptability, and behavioral outcomes from a technology-enhanced behavioral change intervention (prostate 8): a pilot randomized controlled trial in men with prostate cancer. *Eur Urol* 2019; 75: 950–958.
75. Yates T, Davies M, Gorely T, et al. Effectiveness of a pragmatic education program designed to promote walking activity in individuals with impaired glucose tolerance: a randomized controlled trial. *Diabetes Care* 2009; 32: 1404–1410.
76. Yates T, Edwardson CL, Henson J, et al. Walking away from type 2 diabetes: a cluster randomized controlled trial. *Diabet Med* 2017; 34: 698–707.
77. Suboc TB, Strath SJ, Dharmashankar K, et al. Relative importance of step count, intensity, and duration on physical activity's impact on vascular structure and function in previously sedentary older adults. *J Am Heart Assoc* 2014; 3: e000702.
78. Hochsmann C, Muller O, Ambuhl M, et al. Novel smartphone game improves physical activity behavior in type 2 diabetes. *Am J Prev Med* 2019; 57: 41–50.
79. Knight E, Stuckey MI and Petrella RJ. Health promotion through primary care: enhancing self-management with activity prescription and mHealth. *Phys Sportsmed* 2014; 42: 90–99.
80. Volders E, Bolman C, de Groot R, et al. The effect of active plus, a computer-tailored physical activity intervention, on the physical activity of older adults with chronic illness(es)-a cluster randomized controlled trial. *Int J Environ Res Public Health* 2020; 17: 2590.
81. Hospes G, Bossenbroek L, Ten HN, et al. Enhancement of daily physical activity increases physical fitness of outclinic COPD patients: results of an exercise counseling program. *Patient Educ Couns* 2009; 75: 274–278.
82. Maher JP, Sliwinski MJ and Conroy DE. Feasibility and preliminary efficacy of an intervention to reduce older adults' sedentary behavior. *Transl Behav Med* 2017; 7: 52–61.
83. Oliveira JS, Sherrington C, Paul SS, et al. A combined physical activity and fall prevention intervention improved mobility-related goal attainment but not physical activity in older adults: a randomised trial. *J Physiother* 2019; 65: 16–22.
84. De Greef K, Deforche B, Tudor-Locke C, et al. A cognitive-behavioural pedometer-based group intervention on physical activity and sedentary behaviour in individuals with type 2 diabetes. *Health Educ Res* 2010; 25: 724–736.
85. De Greef K, Deforche B, Tudor-Locke C, et al. Increasing physical activity in Belgian type 2 diabetes patients: a three-arm randomized controlled trial. *Int J Behav Med* 2011; 18: 188–198.
86. Poppe L, De Bourdeaudhuij I, Verloigne M, et al. Efficacy of a self-regulation-based electronic and mobile health intervention targeting an active lifestyle in adults having type 2 diabetes and in adults aged 50 years or older: two randomized controlled trials. *J Med Internet Res* 2019; 21: e13363.
87. Bickmore TW, Silliman RA, Nelson K, et al. A randomized controlled trial of an automated exercise coach for older adults. *J Am Geriatr Soc* 2013; 61: 1676–1683.
88. Pinto BM, Goldstein MG, Ashba J, et al. Randomized controlled trial of physical activity counseling for older primary care patients. *Am J Prev Med* 2005; 29: 247–255.
89. Barone GB, Brach JS, Byard T, et al. Reducing sedentary behavior versus increasing moderate-to-vigorous intensity physical activity in older adults. *J Aging Health* 2017; 29: 247–267.
90. Van Dyck D, Herman K, Poppe L, et al. Results of MyPlan 2.0 on physical activity in older belgian adults: randomized controlled trial. *J Med Internet Res* 2019; 21: e13219.
91. Losina E, Collins JE, Deshpande BR, et al. Financial incentives and health coaching to improve physical activity following total knee replacement: a randomized controlled trial. *Arthritis Care Res (Hoboken)* 2018; 70: 732–740.
92. Tanji F, Tomata Y, Abe S, et al. Effect of a financial incentive (shopping point) on increasing the number of daily walking steps among community-dwelling adults in Japan: a randomised controlled trial. *Bmj Open* 2020; 10: e037303.
93. Kullgren JT, Harkins KA, Bellamy SL, et al. A mixed-methods randomized controlled trial of financial incentives and peer networks to promote walking among older adults. *Health Educ Behav* 2014; 41: 43S–50S.

94. Harkins KA, Kullgren JT, Bellamy SL, et al. A Trial of financial and social incentives to increase older adults' walking. *Am J Prev Med* 2017; 52: e123–e130.
95. Strother M, Koepsell K, Song L, et al. Financial incentives and wearable activity monitors to increase ambulation after cystectomy: a randomized controlled trial. *Urol Oncol* 2021; 39: 434.e31–434.e38.
96. Petry NM, Andrade LF, Barry D, et al. A randomized study of reinforcing ambulatory exercise in older adults. *Psychol Aging* 2013; 28: 1164–1173.
97. Chokshi NP, Adusumalli S, Small DS, et al. Loss-framed financial incentives and personalized goal-setting to increase physical activity among ischemic heart disease patients using wearable devices: the ACTIVE REWARD randomized trial. *J Am Heart Assoc* 2018; 7: e009173.
98. Dohrn IM, Hagstromer M, Hellenius ML, et al. Short- and long-term effects of balance training on physical activity in older adults with osteoporosis: a randomized controlled trial. *J Geriatr Phys Ther* 2017; 40: 102–111.
99. Yamashita R, Sato S, Akase R, et al. Effects of social network incentives and financial incentives on physical activity and social capital among older women: a randomized controlled trial. *Bmc Public Health* 2021; 21: 188.
100. Harris T, Kerry SM, Limb ES, et al. Effect of a primary care walking intervention with and without nurse support on physical activity levels in 45- to 75-year-olds: the pedometer and consultation evaluation (PACE-UP) cluster randomised clinical trial. *Plos Med* 2017; 14: e1002210.
101. McMahon SK, Lewis B, Oakes JM, et al. Assessing the effects of interpersonal and intrapersonal behavior change strategies on physical activity in older adults: a factorial experiment. *Ann Behav Med* 2017; 51: 376–390.
102. Alonso-Dominguez R, Patino-Alonso MC, Sanchez-Aguadero N, et al. Effect of a multifactorial intervention on the increase in physical activity in subjects with type 2 diabetes mellitus: a randomized clinical trial (EMID Study). *Eur J Cardiovasc Nurs* 2019; 18: 399–409.
103. Christiansen MB, Thoma LM, Master H, et al. Feasibility and preliminary outcomes of a physical therapist-administered physical activity intervention after total knee replacement. *Arthritis Care Res (Hoboken)* 2020; 72: 661–668.
104. Kolt GS, Schofield GM, Kerse N, et al. Healthy steps trial: pedometer-based advice and physical activity for low-active older adults. *Ann Fam Med* 2012; 10: 206–212.
105. Harris T, Kerry SM, Limb ES, et al. Physical activity levels in adults and older adults 3-4 years after pedometer-based walking interventions: long-term follow-up of participants from two randomised controlled trials in UK primary care. *Plos Med* 2018; 15: e1002526.
106. Nahm ES, Resnick B, Brown C, et al. The effects of an online theory-based bone health program for older adults. *J Appl Gerontol* 2017; 36: 1117–1144.
107. Barnett A, van den Hoek D, Barnett D, et al. Measuring moderate-intensity walking in older adults using the ActiGraph accelerometer. *BMC Geriatr* 2016; 16: 11.
108. Saint-Maurice PF, Troiano RP, Bassett DJ, et al. Association of daily step count and step intensity with mortality among US adults. *JAMA* 2020; 323: 1151–1160.
109. Dwyer T, Ponsonby AL, Ukoumunne OC, et al. Association of change in daily step count over five years with insulin sensitivity and adiposity: population based cohort study. *Br Med J* 2011; 342: c7249.
110. Kraus WE, Janz KF, Powell KE, et al. Daily step counts for measuring physical activity exposure and its relation to health. *Med Sci Sports Exerc* 2019; 51: 1206–1212.
111. Li C, Chen X and Bi X. Wearable activity trackers for promoting physical activity: a systematic meta-analytic review. *Int J Med Inform* 2021; 152: 104487.
112. Wu S, Li G, Du L, et al. The effectiveness of wearable activity trackers for increasing physical activity and reducing sedentary time in older adults: a systematic review and meta-analysis. *Digit Health* 2023; 9: 20552076231176705.
113. Luong MN, Hall M, Bennell KL, et al. The impact of financial incentives on physical activity: a systematic review and meta-analysis. *Am J Health Promot* 2021; 35: 236–249.
114. Yerrakalva D, Yerrakalva D, Hajna S, et al. Effects of mobile health app interventions on sedentary time, physical activity, and fitness in older adults: systematic review and meta-analysis. *J Med Internet Res* 2019; 21: e14343.
115. Muellmann S, Forberger S, Mollers T, et al. Effectiveness of eHealth interventions for the promotion of physical activity in older adults: a systematic review. *Prev Med* 2018; 108: 93–110.
116. Haff N, Patel MS, Lim R, et al. The role of behavioral economic incentive design and demographic characteristics in financial incentive-based approaches to changing health behaviors: a meta-analysis. *Am J Health Promot* 2015; 29: 314–323.
117. Lee BC, Xie J, Ajisafe T, et al. How are wearable activity trackers adopted in older adults? Comparison between subjective adoption attitudes and physical activity performance. *Int J Environ Res Public Health* 2020; 17: 3461.
118. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 2012; 380: 247–257.
119. Nunez DAS, Cavero-Redondo I, Alvarez-Bueno C, et al. Effect of eHealth to increase physical activity in healthy adults over 55 years: a systematic review and meta-analysis. *Scand J Med Sci Sports* 2021; 31: 776–789.
120. Monninghoff A, Kramer JN, Hess AJ, et al. Long-term effectiveness of mHealth physical activity interventions: systematic review and meta-analysis of randomized controlled trials. *J Med Internet Res* 2021; 23: e26699.
121. Chodzko-Zajko WJ, Proctor DN, Fiatarone SM, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc* 2009; 41: 1510–1530.
122. de Vreede PL, van Meeteren NL, Samson MM, et al. The effect of functional tasks exercise and resistance exercise on health-related quality of life and physical activity. A randomised controlled trial. *Gerontology* 2007; 53: 12–20.
123. Thompson WG, Kuhle CL, Koepp GA, et al. "Go4Life" exercise counseling, accelerometer feedback, and activity levels in older people. *Arch Gerontol Geriatr* 2014; 58: 314–319.
124. Mitchell MS, Goodman JM, Alter DA, et al. Financial incentives for exercise adherence in adults: systematic review and meta-analysis. *Am J Prev Med* 2013; 45: 658–667.
125. Matthews CE, George SM, Moore SC, et al. Amount of time spent in sedentary behaviors and cause-specific mortality in US adults. *Am J Clin Nutr* 2012; 95: 437–445.

126. Patterson R, McNamara E, Tainio M, et al. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol* 2018; 33: 811–829.
127. Proper KI, Singh AS, van Mechelen W, et al. Sedentary behaviors and health outcomes among adults: a systematic review of prospective studies. *Am J Prev Med* 2011; 40: 174–182.
128. Ross R, Chaput JP, Giangregorio LM, et al. Canadian 24-hour movement guidelines for adults aged 18-64 years and adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab* 2020; 45: S57–S102.
129. Chase JD, Otmanowski J, Rowland S, et al. A systematic review and meta-analysis of interventions to reduce sedentary behavior among older adults. *Transl Behav Med* 2020; 10: 1078–1085.
130. Chastin S, Gardiner PA, Harvey JA, et al. Interventions for reducing sedentary behaviour in community-dwelling older adults. *Cochrane Database Syst Rev* 2021; 6: CD012784.
131. Szeto K, Arnold J, Singh B, et al. Interventions using wearable activity trackers to improve patient physical activity and other outcomes in adults who are hospitalized: a systematic review and meta-analysis. *JAMA Netw Open* 2023; 6: e2318478.
132. Stockwell S, Schofield P, Fisher A, et al. Digital behavior change interventions to promote physical activity and/or reduce sedentary behavior in older adults: a systematic review and meta-analysis. *Exp Gerontol* 2019; 120: 68–87.