Effects of workplace interventions on sedentary behaviour and physical activity: an umbrella review with meta-analyses and narrative synthesis

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Summary

Background **Physical inactivity is rising globally, exacerbating the burden of preventable deaths and diseases. Despite extensive research on promoting physical activity in the workplace, synthesising the existing literature is challenging due to the wide variety of interventions and outcomes. This study aims to provide a comprehensive synthesis of intervention effects to inform health promotion initiatives and guide future research efforts.**

Methods **In this umbrella review, we conducted systematic searches of six databases (Cochrane, MEDLINE, Embase, CINAHL, Scopus, and Web of Science) for systematic reviews and meta-analyses published between Jan 1, 2000, and May 31, 2024, evaluating workplace interventions targeting sedentary behaviour or physical activity in working adults aged 18 years and older without specific health conditions or mobility impairments. Outcomes encompassed any behavioural changes related to sedentary behaviour or physical activity. Evidence for each relevant combination of intervention and outcome categories was summarised using either meta-analysis or narrative synthesis, with primary study data extracted as needed. This study is registered with PROSPERO, CRD42020171774.**

Findings **We included 36 systematic reviews and meta-analyses covering 214 unique primary studies. Despite considerable heterogeneity in the evidence, several effect trends emerged with moderate-to-high confidence. First, sit-to-stand workstations produced the largest reductions in sedentary time, decreasing it by up to 75 min per day (95% CI –109 to –41) when used alone, with reductions increasing by up to 33% when paired with psychosocial strategies. However, these interventions did not significantly increase physical activity at any intensity. Second, self-monitoring combined with psychosocial strategies yielded the largest increases in step count, with average gains of 1056 steps per day (371 to 1740). Third, no specific strategy consistently increased moderate-to-vigorous physical activity, although the available evidence remains sparse. Additional trends were observed but with lower confidence levels. Analysis of publication bias suggested an inflated effect of environmental-level interventions on occupational sedentary time. Adjusting for this bias using the trim-and-fill method only slightly reduced the effect size, but this result should be interpreted with caution due to high heterogeneity (I^2=84·80%).**

Interpretation **Current evidence highlights the modest effect of existing workplace interventions on physical activity. Some strategies, such as sit-to-stand workstations and gamified interventions, effectively reduce sedentary behaviour and encourage lighter forms of physical activity, but none consistently improves moderate-to-vigorous physical activity, which provides the greatest health benefits. With many countries falling short of the WHO target to reduce physical inactivity prevalence by 15% from 2010 levels by 2030, intensified efforts are needed to address this gap, meet global goals, and alleviate the health burden of physical inactivity.**

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Introduction

In the 21st century, promoting physical activity has emerged as a key priority in global public health policy.[1,2] Despite policy efforts and repeated calls to action, a substantial proportion of the global population still does not meet the WHO recommendation of at least 150 min of moderate-to-vigorous physical activity (MVPA) per week for individuals aged 18–64 years.[3] Recent estimates indicate that in 2022, 31·3% of adults worldwide were insufficiently active, compared with 23·4% in 2000 and 26·4% in 2010.[4] This global pandemic of physical inactivity is a leading cause of mortality, contributing to 4–5 million preventable deaths annually.[5] If current trends persist, about 500 million new cases of preventable non-communicable diseases could occur by 2030, placing a substantial financial burden on health-care systems.[6]

The benefits of regular physical activity are well documented. Both MVPA[7–9] and light-intensity activities, including walking,[7] are associated with reduced risks of all-cause mortality. MVPA provides benefits regardless of how it is accumulated, even in bouts as short as 5 min.[7–9]

Research in context

Evidence before this study

We searched MEDLINE, Scopus, and Web of Science for umbrella reviews published between Jan 1, 2000, and May 31, 2024, using search terms including: (umbrella OR meta* OR "review of systematic reviews" OR "review of reviews") AND (inactiv* OR sedentar* OR activ* OR exercise*) AND (work* OR office* OR occupation* OR employ*). Although numerous systematic reviews and meta-analyses have examined the effects of specific workplace interventions on various physical activity or sedentary behaviour outcomes, we found no umbrella reviews that comprehensively synthesise the existing literature or assess the robustness of the evidence.

Added value of this study

This study offers a comprehensive synthesis of evidence on interventions targeting sedentary behaviour and physical activity. Drawing from 36 systematic reviews and meta-analyses, our study encompasses 214 unique primary studies, 264 interventions, and 573 reported outcome changes. We provide pooled effect estimates for key combinations of intervention and outcome categories, supported by visual aids that clarify evidence certainty and facilitate cross-intervention comparisons. Despite considerable heterogeneity in the evidence, we document clear effect trends with moderate-to-high confidence, and also uncover substantial gaps and limitations in the existing research.

Implications of all the available evidence

Our findings offer robust evidence to guide the development of workplace health promotion initiatives and expose the limitations of existing interventions in increasing physical activity. Although some strategies effectively reduce sedentary time and encourage lighter forms of physical activity—both of which are linked to measurable health benefits—none consistently enhances moderate-to-vigorous physical activity. This finding is concerning, as increasing moderate-to-vigorous physical activity is essential for maximising health benefits and mitigating the harmful effects of sedentary behaviour. With many countries falling short of the WHO 2030 Physical Activity target, intensified efforts are needed to bridge this gap, reach global goals, and reduce the health burden of physical inactivity.

Conversely, sedentary behaviour—characterised by low energy expenditure (<1·5 metabolic equivalents of task) in a sitting or lying posture during waking hours[10]—is associated with elevated risks of mortality and morbidity.[7,11,12] However, engaging in 30–40 min of MVPA daily can mitigate these risks, highlighting the important role of physical activity in offsetting the harmful effects of prolonged sedentary time.[13]

Although global estimates of sedentary time are currently scant, studies from high-income countries have shown concerning trends. In Europe, a large-scale study found that, on average, people accumulate nearly 9 h of sedentary time per day, with 23% exceeding 10 h.[14] In the USA, about one in four adults reports sitting for more than 8 h per day.[15] These findings are alarming, as evidence suggests significantly higher all-cause and cardiovascular mortality risks at these levels.[7,11] Sedentary work environments are a major contributor, with office workers in high-income countries spending an average of 72·5% of their working hours sedentary.[16]

In this context, workplace interventions targeting physical activity and sedentary behaviour have proliferated over the past decade, with numerous systematic reviews synthesising this literature.[17–21] However, identifying the most effective interventions for each relevant physical activity and sedentary behaviour outcome remains challenging for several reasons. First, the wide variety of interventions makes cross-category comparisons difficult, with most reviews focusing on specific subsets of interventions, such as mobile health strategies[18] or activity-permissive workstations.[19] Second, technological advancements have transformed the field, shifting measurement methods from self-reported to objective outcomes. Third, considerable heterogeneity exists among studies in terms of the populations and outcomes they address.

See Online for appendix

With many countries falling behind the WHO target of reducing physical inactivity prevalence by 15% from 2010 levels by 2030,[4] effective strategies are urgently needed to address population movement behaviours and alleviate the associated heath and economic burdens. Urbanisation and technological advancements have created increasingly sedentary work environments, making workplaces a prominent setting for sedentary time accumulation. Providing policy makers and employers with robust, comparative evidence on the effects of workplace interventions targeting physical activity and sedentary behaviour is, therefore, essential. This study aims to comprehensively synthesise the existing literature, offering actionable evidence to inform health promotion initiatives and guide future research efforts.

Methods

Search strategy and selection criteria

In this umbrella review with meta-analysis and narrative synthesis, we searched six databases (Cochrane, MEDLINE, Embase, CINAHL, Scopus, and Web of Science) for peer-reviewed articles published between Jan 1, 2000, and April 1, 2022. Grey literature was obtained from the Sedentary Behaviour Research Network's Sedentary Research Database. The search terms focused on three themes: study design (eg, "systematic review"), outcome (eg, "sedentary behaviour"), and setting (eg, "workplace"; appendix p 8). Reference lists of included studies were screened for further relevant publications, and forward citation searches were conducted to update results up to May 31, 2024. The population of interest included working adults aged 18 years and older without specific health conditions or mobility impairments. Eligible interventions aimed to reduce sedentary behaviour or increase physical activity in workplace settings. Outcomes encompassed any behavioural changes related to sedentary behaviour or physical activity. Only systematic reviews, with or without meta-analysis, and without restrictions on primary study design, were included. The methodology followed the Cochrane guidelines,[22] and details are available in the published protocol[23] and appendix (pp 3–20). This study is registered with PROSPERO, CRD42020171774.

Data analysis

Two reviewers independently screened titles, abstracts, and full-text articles (KA and AVD), extracted data (SK and SVD), and assessed the risk of bias of included reviews (EY and AVD). Discrepancies were resolved through consensus or discussion with a third reviewer (TR or AMM). The risk of bias was evaluated using AMSTAR-2, a tool specifically designed to appraise the methodological quality of systematic reviews involving both randomised and non-randomised studies.[24] The corrected covered area index was calculated to measure overlap in primary studies across included reviews (appendix p 3).[25]

We structured the evidence synthesis by categorising interventions according to the social-ecological model,[26] grouping them into individual, interpersonal, organisational, and environmental levels, as specified in the protocol. To address challenges in comparing intervention effects using only review-level data, we also re-extracted data from primary studies as needed.

We conducted post-hoc meta-analyses to evaluate intervention effects using the same categorisation framework. Pooled effects were estimated on the basis of the number of datapoints available and the quality of the primary studies. To ensure reliability, only studies with relatively low risk of bias were included. Eligibility was determined by two criteria: the presence of a control group with random allocation to treatment, and the use of objectively measured outcomes. Self-reported measures were excluded due to their susceptibility to social desirability and recall biases, which might compromise reliability and validity.[27] To explore heterogeneity through meaningful subgroup analyses and metaregressions, a minimum of ten datapoints per outcome were required.[28] Additionally, to facilitate cross-level comparisons, only studies in which the control group received no or minimal intervention were included. Small-study effects were assessed using Egger's test for funnel plot symmetry,[29] and potential publication bias was addressed using the trim-and-fill method.[30] Detailed methodological information is

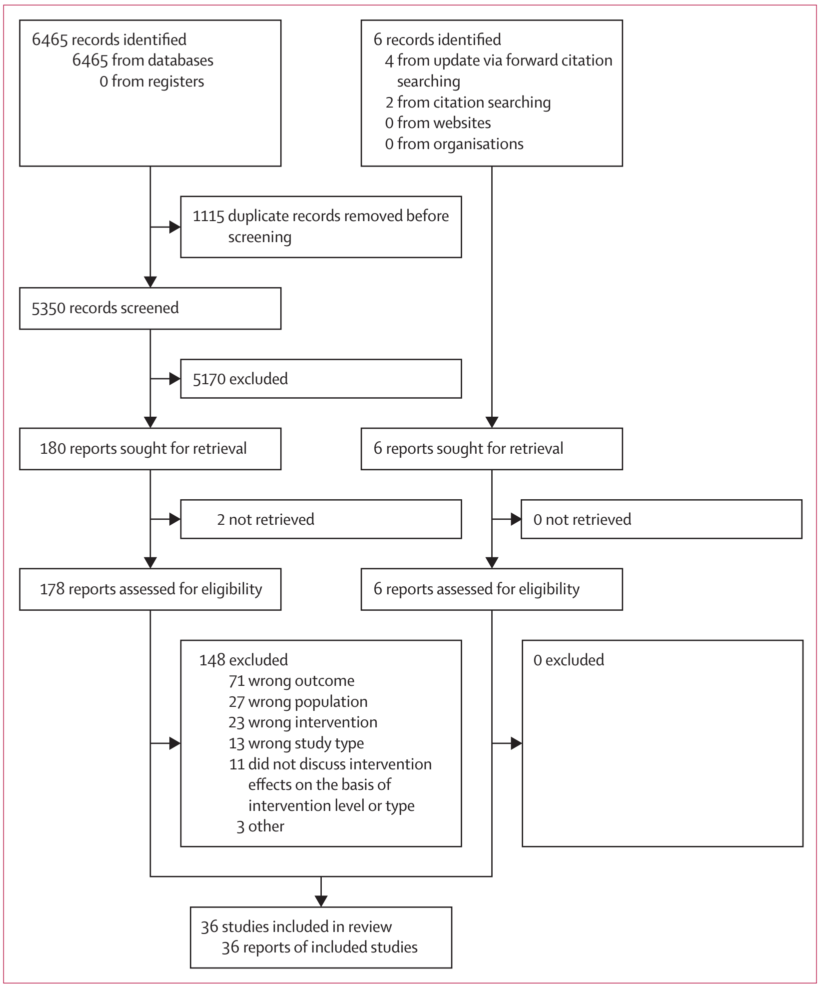


Figure 1: **Study selection**

provided in the appendix (p 4). The certainty of evidence was assessed using the GRADE system (appendix p 6).[31]

For primary studies that were not included in the meta-analyses, we calculated the proportion of statistically significant outcome changes that favour the intervention and plotted the results by intervention level. These plots provide a high-level overview, complementing the meta-analyses with a visual summary of intervention effects across levels.

The findings were summarised based on confidence in the body of evidence, incorporating both primary-level and review-level data. A colour-coding system was used to facilitate visual interpretation of the results.[32] Confidence levels for each relevant combination of intervention and outcome were classified into five tiers (appendix p 9).

Deviations from the published protocol

Initially, we intended to summarise evidence using narrative synthesis only. However, after extracting data at the review level, we decided to conduct additional post-hoc

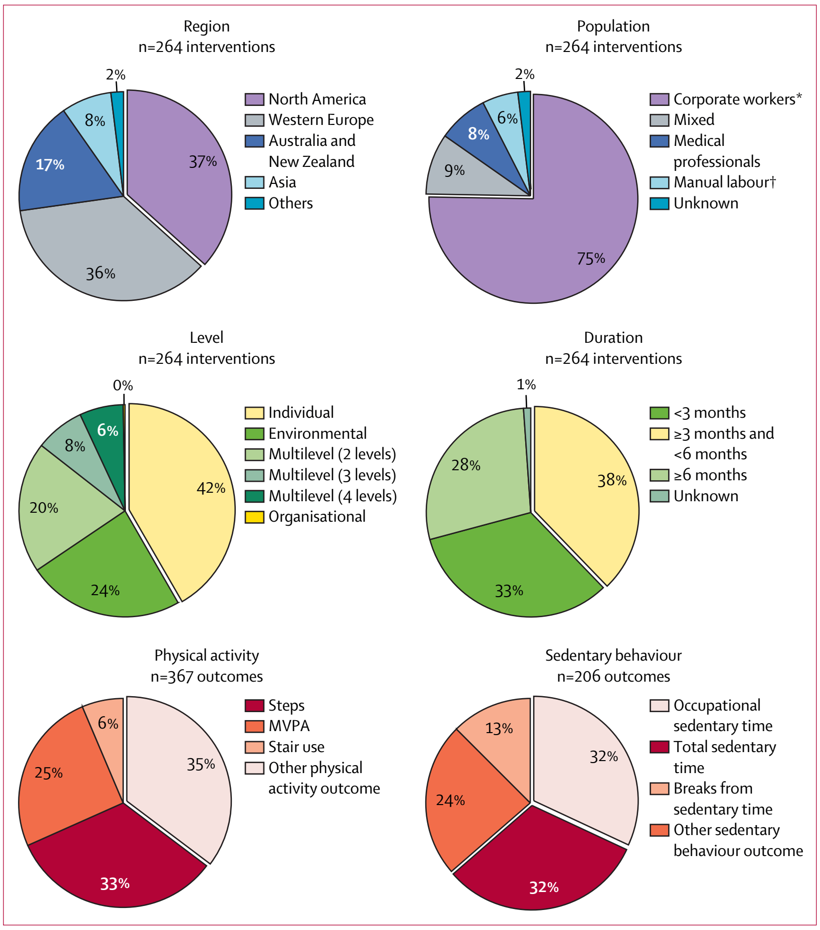


Figure 2: **Descriptive statistics of the overall body of evidence**
Upper row: distribution of interventions by region (left column) and target population (right column). Middle row: distribution of interventions by target level (left column) and duration (right column). Lower row: distribution of physical activity (left column) and sedentary behaviour (right column) outcomes by type measured. MVPA=moderate-to-vigorous physical activity. *Individuals primarily engaged in desk-based activities typically done in an office setting. †Individuals whose primary responsibilities involve physical labour, including both skilled and unskilled roles.

meta-analyses on primary studies for three reasons. First, inconsistent definitions and categorisations of interventions across reviews created challenges in evidence synthesis. Second, meta-analytic data were insufficient for several intervention–outcome combinations, hindering our ability to compare effect sizes and make specific recommendations. Third, substantial primary study overlaps in certain intervention categories precluded second-order meta-analyses (ie, meta-analyses of meta-analytic results).[22] Furthermore, we did not restrict the synthesis to changes occurring exclusively during working hours, as physical activity outcomes were often reported on a daily or weekly basis. Finally, to ensure comprehensiveness, the reference search for reviews was extended to April 1, 2022, and updated through forward citation searching on May 31, 2024. For primary studies, forward citation searching was conducted for both reviews and the primary studies included in the meta-analysis, with the search period extended to June 30, 2024.

Role of the funding source
There was no funding source for this study.

Results
The literature search identified 5350 unique references. Of 178 potentially eligible systematic reviews, 30 were included (figure 1). The 148 excluded systematic reviews and reasons for exclusion are detailed in the appendix (pp 10–16). Citation searching identified six additional eligible reviews, bringing the total to 36.[17–19,33–65] The characteristics of the included reviews are in the appendix (pp 17–20). Only 12 (33%) reviews provided meta-analytic data.[17,19,33–42] Target populations ranged from all professionally active adults (n=18 [50%]) to subgroups such as desk-based corporate workers (n=11 [31%]). Five (14%) reviews included working subgroups but did not specifically target active individuals. 17 (47%) reviews focused on environmental-level interventions, particularly sit-to-stand or activity-permissive workstations (n=9 [25%]). Seven reviews addressed individual-level interventions: three on mobile health strategies, two on self-monitoring, one on coaching, and one on computer prompts. 12 (33%) reviews did not restrict their scope to specific intervention types. Outcomes were evenly distributed, with 12 (33%) reviews each targeting physical activity, sedentary behaviour, or both. Only three (8%) reviews restricted outcome changes to objectively measured behaviours.[37,38,61] Seven (19%) reviews reported multiple primary outcomes, some including non-behavioural outcomes such as physiological measures.

The appendix (pp 21–22) outlines the methodological quality of the included reviews. The quality was generally low: 14 (39%) reviews were rated as high (n=2 [6%]) or moderate (n=12 [33%]), nine (25%) as low, and 13 (36%) as critically low. The appendix (p 71) provides a breakdown of adherence to AMSTAR-2 criteria. Most reviews (n=29 [81%]) clearly described their population, intervention, comparator, and outcome elements, but 17 (53%) did not have sufficient detail on eligibility criteria and descriptions of included primary studies.

We identified 214 unique primary studies (264 interventions) from the included reviews. Of these studies, 53 (25%) studies (67 interventions) were included in the meta-analyses (pp 23–30), whereas the remaining 161 (75%) studies (197 interventions) were synthesised narratively (pp 31–50). Figure 2 and the appendix (p 72) provide an overview of this evidence base. Most interventions (n=238 [90%]) were conducted in North America, western Europe, and Australia and New Zealand; evidence from Asia is growing, with 18 of the 21 interventions implemented after 2015. Evidence from other regions was minimal (n=5 [2%]). Target populations often included desk-based corporate workers (n=198 [75%]), with predominantly female samples (n=164 [62%]). Most interventions focused on the individual level of the social-ecological model (n=111

[42%]), followed by multilevel interventions (n=90 [34%]). Outcomes assessed across these studies were highly heterogeneous. The most commonly reported sedentary behaviour outcomes were occupational sedentary time (66 [32%] of 206 outcomes) and total sedentary time (66 [32%] of 206 outcomes), whereas step count was the most frequently reported physical activity outcome (121 [33%] of 367 outcomes). To facilitate the reporting of results and manage the wide range of identified intervention components, we grouped similar components into categories (table).

The citation matrix (appendix pp 51–52) highlights the extent of overlap among the 53 primary studies included in the meta-analyses. Multilevel interventions targeting three levels showed the greatest overlap (corrected covered area index 0·11), whereas other intervention levels showed low-to-moderate overlap. Where substantial overlap occurred, the reviews generally shared similar objectives and outcomes. No major discrepancies were observed in the authors' conclusions, indicating consistency in the interpretation of findings across overlapping studies.

We identified sufficient datapoints to conduct meta-analyses on two physical activity outcomes—daily step count and MVPA—and three sedentary behaviour outcomes—occupational sedentary time, total sedentary time, and breaks from sedentary time. The results are presented in forest plots (figure 3; appendix pp 73, 81–83). For physical activity outcomes, step count data were available for 44 interventions, involving 3735 participants in intervention groups and 2408 in control groups (figure 3). MVPA data were reported for 15 interventions, with 1246 participants in intervention groups and 831 in control groups (appendix p 73). For sedentary behaviour outcomes, occupational sedentary time was assessed for 20 interventions (974 participants in intervention groups and 814 in control groups; appendix p 81), total sedentary time for 17 interventions (1038 participants in intervention groups and 752 in control groups; appendix p 82), and breaks from sedentary time for 13 interventions (484 participants in intervention groups and 397 in control groups; appendix p 83).

Individual-level interventions significantly improved step count, with a mean difference of 904 steps per day (95% CI 542–1267, I^2=93·9%, p<0·0001). Multilevel interventions also showed significant improvements, with a mean difference of 593 steps per day (323–864, I^2=60·2%, p<0·0001). However, environmental-level interventions had no significant effect. For MVPA, individual-level interventions resulted in a favourable mean difference of 15·4 min per week (0·9–29·9, I^2=0·0%, p=0·038). Environmental-level interventions also showed a significant effect (mean difference 9·3 [1·5–17·1], I^2=0·0%, p=0·019), although this finding was based on only two studies with a high risk of bias. Sensitivity analyses confirmed these findings, with no single large study disproportionately influencing the results (appendix pp 74–75). Pooled effects remained consistent after excluding studies with sample sizes of 100 or less, although small-to-moderate reductions in effect size were observed (appendix pp 76–77). Specifically, effects on step count decreased by about 25% for both individual-level interventions (mean difference 682 [275–1089], n=9) and multilevel interventions (mean difference 450 [280–619], n=10). Sensitivity analyses for environmental-level interventions were sparse due to the small number of studies with sample sizes of more than 100. Results from fixed-effects models were consistent, except for the modest effect of multilevel interventions on MVPA, which became significant (appendix pp 78–80).

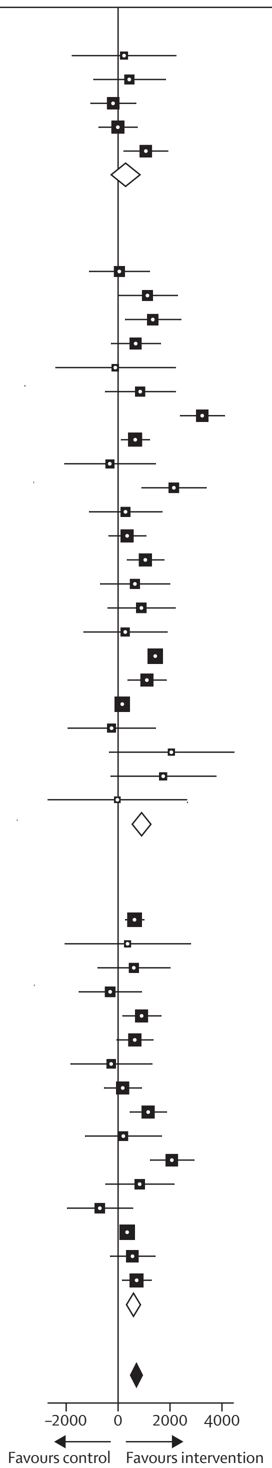
Environmental-level interventions had the largest reductions in occupational sedentary time (mean difference –74·7 min per 8 h workday [95% CI –108·5 to –40·9], I^2=84·8%, p<0·0001) and total sedentary time (mean difference –79·5 min per day [–124·3 to –34·6], I^2=72·5%, p=0·0005). However, several

	Code*	Component examples
Individual level		
Self-monitoring	A	Wearable activity trackers; activity logs
Psychosocial	B	Coaching; counselling; motivational interviewing; goal setting
Exercise	C	Exercise programmes; scheduled active breaks
Digital reminders	D	Computer prompts; wearable device alerts; cushion with built-in sensors
Financial incentives	$	Conditional rewards; deposit contracts
Interpersonal level		
Social strategy	I	Team-based challenges; competition; peer effects; buddy systems
Organisational level		
Organisational strategy	O	Management support; active meeting policy
Environmental level		
Sit-to-stand workstation	E	Individual height-adjustable desks
Active workstation	F	Individual active desks, such as treadmill desks or cycling desks
Active building design	G	Staircase accessibility and appeal; walking routes; active meeting spaces; shared standing, height-adjustable, or active desks; exercise rooms
Visual prompts	H	Motivational posters; floor decals; interactive signage

*These codes are used in the Results section to link the findings with the figures and table, for improved clarity and space efficiency.

Table: **Categorisation of intervention components by level of the social-ecological model** studies contributing to these results had a high risk of bias. Multilevel interventions yielded smaller but still statistically significant reductions, about one-third the size of those observed with environmental-level interventions. In contrast, individual-level interventions showed no significant effects. No intervention categories

	Country	Size	Components	Weeks	Mean difference (95% CI)	Weight, %	Risk of bias
Environmental level							
MacEwen, 2017	Canada	25	E	12	231·00 (–1787·11 to 2249·11)	0·99	High
Miyachi, 2015	Japan	62	E	6	431·00 (–958·71 to 1820·71)	1·67	High
Li, 2017	Australia	26	E	4	–194·00 (–1064·86 to 676·86)	2·67	High
Tobin, 2016	Australia	37	E	5	–8·10 (–748·80 to 732·60)	2·99	Some concerns
Ma, 2021	Japan	74	E	12	1070·00 (204·00 to 1936·00)	2·68	High
Heterogeneity: τ^2=125 966·28, I^2=31·89%, H^2=1·47					289·78 (–267·72 to 847·28)		
Test of $\theta_i=\theta_j$: Q(4)=4·96, p=0·29							
Test of θ=0: Z=1·02, p=0·31							
Individual level							
Aittasalo, 2004	Finland	152	B	48	48·00 (–1110·96 to 1206·96)	2·05	Some concerns
Compernolle, 2015	Belgium	195	AB	12	1133·00 (–13·36 to 2279·36)	2·08	High
Furukawa, 2003	Japan	49	C	12	1339·00 (267·32 to 2410·68)	2·22	Some concerns
Gell, 2015	USA	87	B	24	679·00 (–274·18 to 1632·18)	2·48	High
Gilson, 2007 (1)	UK	43	B	10	–106·00 (–2418·25 to 2206·25)	0·80	High
Gilson, 2009 (1)	UK	120	B	10	852·00 (–502·59 to 2206·59)	1·72	High
Mansi, 2015	New Zealand	58	AB	12	3241·00 (2383·84 to 4098·16)	2·70	High
Poirier, 2016	USA	217	AB	6	660·00 (110·63 to 1209·37)	3·48	Some concerns
Simons, 2018	Belgium	118	AB	9	–320·00 (–2077·90 to 1437·90)	1·21	Low
Speck and Looney, 2001	USA	49	A	12	2148·00 (906·89 to 3389·11)	1·90	High
Thorndike, 2014	USA	99	A	6	286·00 (–1115·91 to 1687·91)	1·65	Low
Finkelstein, 2016 (1)	Singapore	404	A	24	350·00 (–364·96 to 1064·96)	3·05	Low
Finkelstein, 2016 (3)	Singapore	398	A-$	24	1050·00 (340·53 to 1759·47)	3·07	Low
Maruyama, 2010	Japan	66	B	16	649·00 (–686·25 to 1984·25)	1·75	High
Pillay, 2014	South Africa	19	AB	10	899·00 (–398·24 to 2196·24)	1·81	Some concerns
Puig-Ribera, 2008 (1)	Spain	45	AB	9	277·00 (–1331·20 to 1885·20)	1·38	High
Puig-Ribera, 2015	Spain	198	AB	19	1432·00 (1359·62 to 1504·38)	4·34	High
Ribeiro, 2014 (1)	Brazil	100	AB	12	1109·00 (367·84 to 1850·16)	2·99	High
Alshagrawi and Abidi, 2023	Saudi Arabia	327	ABD	12	161·60 (83·03 to 240·17)	4·34	Some concerns
Gonzales, 2024 (1)	USA	73	AB	36	–251·00 (–1935·26 to 1433·26)	1·29	High
Gonzales, 2024 (2)	USA	81	A-$	36	2052·00 (–351·28 to 4455·28)	0·75	High
Gonzales, 2024 (3)	USA	71	AB-$	36	1738·00 (–287·06 to 3763·06)	0·98	High
Carter, 2020	UK	14	BD	8	–27·00 (–2716·71 to 2662·71)	0·62	High
Heterogeneity: τ^2=431 905·06, I^2=93·86%, H^2=16·28					904·45 (542·10 to 1266·80)		
Test of $\theta_i=\theta_j$: Q(22)=590·72, p=0·00							
Test of q=θ: Z=4·89, p=0·00							
Multilevel							
Danquah, 2017	Multiple	317	BEGIO	12	632·00 (274·67 to 989·33)	3·94	Low
Gilson, 2007 (2)	UK	43	BI	10	365·00 (–2060·02 to 2790·02)	0·74	High
Gilson, 2009 (2)	UK	119	BI	10	605·00 (–789·10 to 1999·10)	1·66	High
Hallman, 2017	Denmark	116	CI	16	–304·00 (–1510·39 to 902·39)	1·96	High
Johannesson, 2010 (1)	Sweden	1048	AI	16	907·00 (168·20 to 1645·80)	2·99	Low
Johannesson, 2010 (2)	Sweden	1020	AI-$	16	643·00 (–56·66 to 1342·66)	3·09	Low
Michishita, 2017	Japan	130	CI	8	–267·00 (–1830·91 to 1296·91)	1·43	High
Finkelstein, 2016 (2)	Singapore	400	AI	24	180·00 (–538·77 to 898·77)	3·04	Low
Maylor, 2018$	UK	68	ABDEO-$	8	1160·00 (455·82 to 1864·18)	3·08	Some concerns
Puig-Ribera, 2008 (2)	Spain	51	ABI	9	203·00 (–1265·08 to 1671·08)	1·55	High
Ribeiro, 2014 (2)	Brazil	95	ABI	12	2072·00 (1230·32 to 2913·68)	2·74	High
Ribeiro, 2014 (3)	Brazil	94	CI	12	831·00 (–487·41 to 2149·41)	1·77	High
Júdice, 2024	Portugal	38	BE	24	–703·10 (–1965·79 to 559·59)	1·87	Some concerns
Cheah, 2024	Malaysia	148	ABHIO	24	350·30 (306·80 to 393·80)	4·36	High
Renaud, 2020	Netherlands	242	ABGO	32	555·00 (–305·84 to 1415·84)	2·69	Low
Akksilp, 2022	Thailand	282	ACDHIO-$	24	716·00 (157·57 to 1274·43)	3·46	Low
Heterogeneity: τ^2=120956·81, I^2=60·21%, H^2=2·51					593·14 (322·56 to 863·73)		
Test of $\theta_i=\theta_j$: Q(15)=33·11, p=0·00							
Test of θ=0: Z=4·30, p=0·00							
Overall					707·83 (479·76 to 935·90)		
Heterogeneity: τ^2= 310420·14, I^2=93·98%, H^2=16·60							
Test of $\theta_i=\theta_j$: Q(43)=834·98, p=0·00							
Test of θ=0: Z=6·08, p=0·00							
Test of group differences: $Q_b(2)$=3·67, p=0·16							
Random-effects restricted maximum likelihood model							



significantly increased breaks from sedentary time. Sensitivity analyses supported the main findings but also revealed limitations in the evidence base. Notably, no studies with sample sizes of more than 100 tested individual-level or environmental-level interventions for any sedentary behaviour outcomes; only multilevel interventions were evaluated in such studies. Excluding small-sample studies resulted in only minimal changes to the pooled effects (appendix pp 84–86). Results were also not disproportionately influenced by any single large study (appendix pp 87–89), and findings remained consistent in fixed-effects models (appendix pp 90–92).

Funnel plots assessing small-study effects and publication bias are presented in the appendix (pp 93–97). Egger's tests indicated small-study effects for occupational sedentary time (p=0·0012) and breaks from sedentary time (p=0·0003). Analysis of publication bias by intervention level suggested an inflated effect of environmental-level interventions on occupational sedentary time (appendix p 98). Adjusting for this bias using the trim-and-fill method only slightly reduced the effect size (mean difference –67·0 min per day [–101·7 to –32·3]). However, this result should be interpreted with caution due to high heterogeneity (I^2=84·80%), which could affect the reliability of the method.[66]

Heterogeneity was moderate to high across all intervention–outcome combinations where at least ten datapoints were pooled. Subgroup analyses by risk of bias, intervention duration, and intervention components are presented in the appendix (pp 99–125). First, studies with high risk of bias tended to report larger effect sizes. For step count, the pooled effect in studies with high risk of bias (mean difference 871 [494–1248], n=26) was 1·7 times greater than in those with low risk of bias (mean difference 513 [310–716], n=18), driven primarily by individual-level interventions. These interventions showed effect sizes more than double in studies with high risk of bias (mean difference 1208 [680–1738], n=14) compared with those with low risk of bias (mean difference 487 [164–811], n=9; appendix pp 105–06). Notably, studies with high risk of bias were also the only ones to report significantly positive effects on MVPA and breaks from sedentary time.

Second, the influence of intervention duration varied by outcome (appendix pp 107–13). For step count, longer interventions (>3 months) had nearly double the pooled effect compared with shorter ones (≤3 months), with mean difference 842 steps per day (95% CI 546 to 1139, n=28) versus 424 steps per day (111 to 736, n=16). This trend was mainly driven by individual-level interventions (appendix p 112) rather than multilevel ones (appendix p 113). However, the subgroup difference for individual-level interventions was not statistically significant (p=0·088), and estimates for multilevel interventions were imprecise. For total sedentary time, statistically significant reductions were observed only in longer interventions (mean difference –48·2 [–68·5 to –27·9], n=13). In contrast, shorter interventions tended to have larger effect sizes for occupational sedentary time and MVPA, although these findings require cautious interpretation due to high risk of bias in most studies (five of eight for occupational sedentary time, and four of five for MVPA). Metaregressions using intervention duration as a continuous moderator (weeks) did not yield significant results across outcomes.

Finally, despite the wide variety of intervention components, clear effect trends emerged (appendix pp 114–26). First, as a standalone component, self-monitoring did not show significant effects on step count (mean difference 890 [95% CI –268 to 2048], n=3; table, appendix pp 114–15, A). However, combining self-monitoring with psychosocial components (mean difference 1056 [371 to 1740], n=9; appendix pp 114–15, AB) or financial incentives (mean difference 1130 [450 to 1811], n=2; appendix pp 114–15, A-$), appeared effective. For MVPA, one high-quality study[67] found self-monitoring effective when combined with financial incentives (mean difference 29·0 [2·5 to 55·5]; appendix pp 114–15, A-$) but not as a standalone intervention (mean difference 16·0 [–9·9 to 41·9]; appendix pp 114–15, A). Second, when newly introduced and used alone, sit-to-stand workstations showed no significant effect on step count (mean difference 290 [–268 to 847], n=5; figure 3, E) but significantly reduced occupational sedentary time (mean difference –74·7 [–108·5 to –40·9], n=8; appendix p 121, E) and total sedentary time (mean difference –54·7 [–95·1 to –14·3], n=3; appendix p 124, E).

The GRADE assessment (appendix pp 53–55) rated the certainty of evidence as high for one intervention–outcome combination (multilevel interventions on occupational sedentary time), moderate for three (multilevel interventions on step count and total sedentary time; individual-level interventions on step

***Figure 3:* Meta-analysis of intervention effects on step count, stratified by intervention level**
Details of listed studies are in the appendix (pp 23–28). Intervention-level stratifications are environmental, individual, and multilevel. Pooled effect sizes were estimated using the restricted maximum likelihood method within a random-effects meta-analysis model. Mean differences (95% CIs) in step count are shown between the intervention and control groups. Squares represent the effect sizes for each study, with their size proportional to the study's weight in the analysis. Study weight reflects each study's contribution to the overall pooled estimate, determined by inverse variance weighting in the random-effects model. Size refers to the total sample size (intervention and control groups) for each evaluation. Components specifies the intervention components included (table): A—self-monitoring, B—psychosocial, C—exercise, D—digital reminders, $—financial incentives, E—sit-to-stand workstation, F—active workstation, G—active building design, H—visual prompts, I—interpersonal or social strategy, O—organisational strategy. Weeks represents the duration of the intervention in weeks. Statistical heterogeneity was assessed using the I^2 statistic (percentage of total variation due to heterogeneity), τ^2 (variance of true effect sizes), and Cochran's Q statistic (p≤0·05 indicates significant heterogeneity). The test of θ=0 evaluates whether the overall effect size significantly differs from zero (indicating no effect).

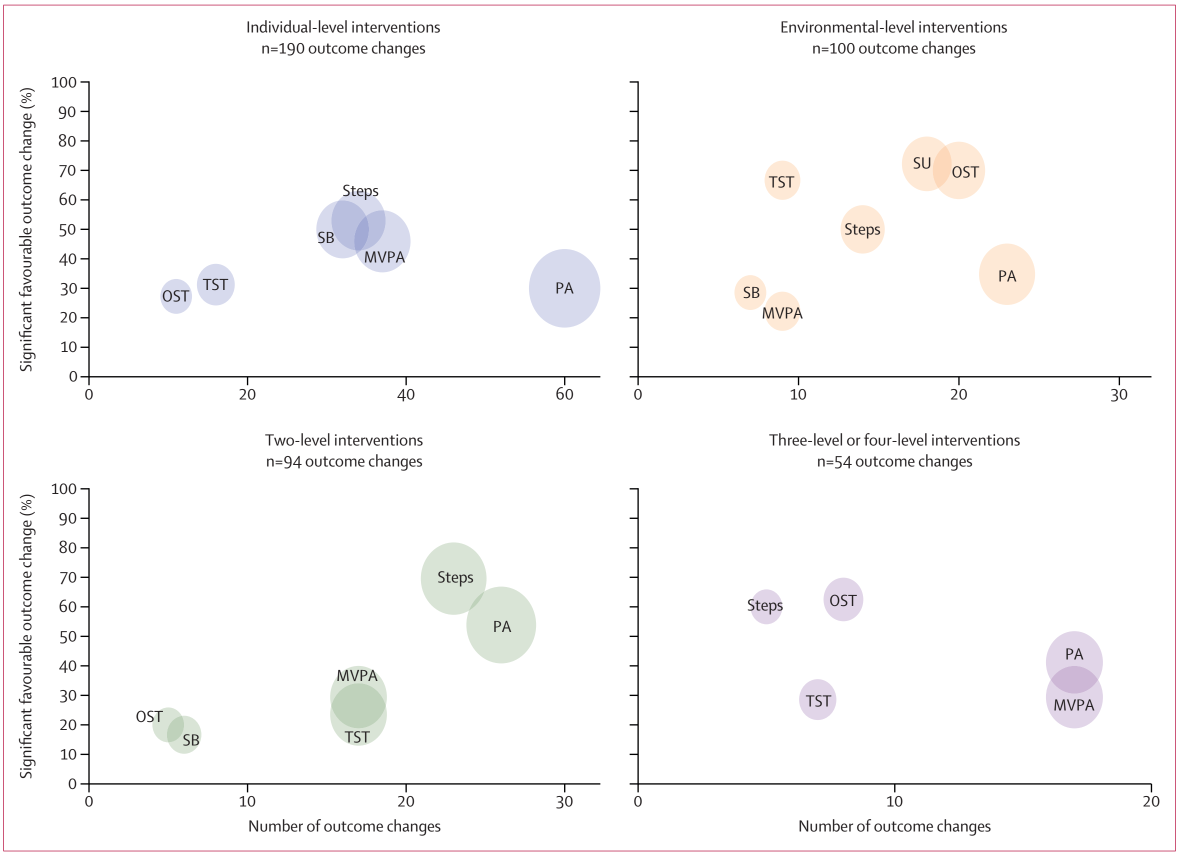


Figure 4: **Proportions of statistically significant favourable outcome changes from interventions not included in the meta-analysis, categorised by intervention level**

Each dot represents a specific outcome category, and the size of each dot is proportional to the aggregated number of outcome changes for the corresponding category. The x-axis shows the number of outcome changes within each intervention level, and the y-axis represents the percentage of those changes that are statistically significant and favour the intervention. MVPA=moderate-to-vigorous physical activity. OST=occupational sedentary time. PA=other physical activity outcomes. SB=other sedentary behaviour outcomes. Steps=step count. SU=stair use. TST=total sedentary time.

count), and low or very low for the remaining ten combinations. The primary reasons for downgrades were the high proportion of studies with high risk of bias and imprecision due to small sample sizes.

The narrative synthesis results are shown in figure 4. Consistent with the meta-analyses, individual-level interventions were most frequently associated with increases in MVPA, with 17 (46%) of 37 reported outcomes showing statistically significant improvements, followed by ten (29%) of 34 multilevel interventions. For step count, multilevel interventions were linked to the most favourable outcomes, with 19 (68%) of 28 reported outcomes showing significant improvements. For sedentary behaviour, the findings closely aligned with those from the meta-analyses. Environmental-level interventions were associated with reductions in sedentary time (occupational or total) in 20 (69%) of 29 outcomes, outperforming both multilevel interventions (12 [32%] of 37) and individual-level interventions (eight [30%] of 27). However, all these results should be interpreted with caution due to limitations in the design and measurement methods of the primary studies. Among all reported outcomes, objective measurement tools—widely regarded as more valid than self-reported methods[68]—were used in 242 (52%) of 463 outcomes, whereas self-reported methods were used in 221 (48%; appendix pp 31–50). Additional details, including key findings from each systematic review, are provided in the appendix (pp 56–70). Finally, the findings from this umbrella review are summarised by intervention level in figure 5 and by component in the appendix (p 127).

Discussion

This umbrella review is the first to comprehensively summarise the effects of workplace interventions targeting sedentary behaviour and physical activity. Such a synthesis was timely for several reasons. First, recent

Figure 5: **Summary of findings by intervention level**
Findings and confidence in the body of evidence, using both primary study-level and review-level data (rating decision process outlined in the appendix p 9). MD=mean difference in outcomes between intervention and control groups (95% CI). MVPA=moderate-to-vigorous physical activity. OST=occupational sedentary time. TST=total sedentary time.

Positive effect, high confidence | Positive effect, moderate confidence | Positive effect, low confidence | No effect, moderate confidence | No effect, low confidence

Domain	Outcome	Summary of evidence
Individual-level interventions (components: self-monitoring, psychosocial, exercise, digital reminders)		
Physical activity	Step count	• Pooled effect: MD=682 steps/day (275 to 1089), based on nine randomised controlled trials (small studies excluded), GRADE=moderate certainty • One other meta-analysis[37] reported similar effects, based on nine studies (six different) • Narrative synthesis: primary studies reported 18 (53%) of 34 significant favourable differences
	MVPA	• Pooled effect: MD=15·4 min/week (0·9 to 29·9), based on five randomised controlled trials, GRADE=low certainty • Narrative synthesis: primary studies reported 17 (46%) of 37 significant favourable differences • No other meta-analysis or narrative synthesis available
	Other	• Narrative synthesis: primary studies reported 18 (30%) of 60 significant favourable differences • One meta-analysis[36] reported small, significant effect (multiple physical activity outcomes): standardised MD=0·22 (0·03 to 0·41) • Two other narrative syntheses[18,49] reported mixed results (multiple physical activity outcomes)
Sedentary behaviour	Sedentary time	• Pooled effect (occupational): MD=–23·3 min/8 h workday (–48·1 to 1·6), based on three randomised controlled trials, GRADE=low certainty • Two other meta-analyses reported similar, significant effects, based on 12 studies (11 different)[33] and seven studies (five different)[40] • Narrative synthesis: primary studies reported eight (30%) of 27 significant favourable differences
	Breaks from sedentary time	• Pooled effect: MD=0·4 break/work hour (–0·1 to 0·9), based on four randomised controlled trials, GRADE=low certainty • Narrative synthesis: primary studies reported one (33%) of three significant favourable differences • No other meta-analysis or narrative synthesis available
	Other	• Narrative synthesis: primary studies reported 16 (50%) of 32 significant favourable differences • No meta-analysis or other narrative synthesis available
Environmental-level interventions (components: sit-to-stand workstation, active workstation, active building design, visual prompts)		
Physical activity	Step count	• Pooled effect: MD=289·8 steps/day (–267·7 to 847·3), based on five randomised controlled trials, GRADE=very low certainty • Narrative synthesis: primary studies reported seven (50%) of 14 significant favourable differences • No other meta-analysis or narrative synthesis available, but one meta-analysis[17] also reported non-significant effects on stepping time based on eight studies (six different)
	MVPA	• Pooled effect: MD=9·3 min/week (1·5 to 17·1), based on two randomised controlled trials, GRADE=very low certainty • Narrative synthesis: primary studies reported two (22%) of nine significant favourable differences • One other narrative synthesis[55] reported similar results
	Stair use	• Narrative synthesis: primary studies reported 13 (72%) of 18 significant favourable differences, 11 (73%) of 15 using visual prompts and two (67%) of three using active building design components • No meta-analysis available
	Other	• Narrative synthesis: primary studies reported eight (35%) of 23 significant favourable differences • No meta-analysis or other narrative synthesis available
Sedentary behaviour	Sedentary time	• Pooled effect (occupational): MD=–74·7 min/8 h workday (–108·5 to –40·9), based on eight randomised controlled trials, GRADE=low certainty • Pooled effect (total): –79·5 min/day (–124·3 to –34·6), based on four randomised controlled trials, GRADE=low certainty • Two other meta-analyses reported similar effects, one pairwise meta-analysis[33] based on six studies (four different), and one network meta-analysis[41] based on seven studies (five different) • Narrative synthesis: primary studies reported 20 (69%) of 29 favourable significant differences on either OST or TST
	Breaks from sedentary time	• Pooled effect: MD=0·9 break/work hour (–1·1 to 3·0), based on three randomised controlled trials, GRADE=very low certainty • Narrative synthesis: only two primary studies available, both reported significant favourable differences • No other meta-analysis available
	Other	• Narrative synthesis: primary studies reported only two (29%) of seven significant favourable differences • No other meta-analysis or narrative synthesis available
Multilevel interventions (two-level, three-level, or four-level interventions)		
Physical activity	Step count	• Pooled effect: MD=450 steps/day (280 to 619), based on 10 randomised controlled trials (small studies excluded), GRADE=moderate certainty • Narrative synthesis: primary studies reported 19 (68%) of 28 significant favourable differences • No other meta-analysis or narrative synthesis available, but one meta-analysis[42] reported non-significant effects on stepping time based on eight studies (seven different)
	MVPA	• Pooled effect: MD=7·4 min/week (–2·0 to 16·8), based on nine randomised controlled trials, GRADE=low certainty • Narrative synthesis: primary studies reported ten (29%) of 34 significant favourable differences • No other meta-analysis or narrative synthesis available
	Other	• Narrative synthesis: primary studies reported 21 (49%) of 43 significant favourable differences • No meta-analysis or other narrative synthesis available
Sedentary behaviour	Sedentary time	• Pooled effect (occupational): MD=–21·4 min/8 h workday (–33·6 to –9·2), based on 9 randomised controlled trials, GRADE=high certainty • Pooled effect (total): –36·8 min/day (–59·3 to –14·3), based on six randomised controlled trials (small studies excluded), GRADE=moderate certainty • Four other pairwise meta-analyses reported similar[34,39,40] or larger effects,[42] and one network meta-analysis[41] reported large effects • Narrative synthesis: primary studies reported seven (47%) of 15 favourable significant differences on either OST or TST for three-level or four-level interventions, but only five (23%) of 22 for two-level interventions
	Breaks from sedentary time	• Pooled effect: MD=1·4 break/work hour (–0·2 to 3·0), based on six randomised controlled trials, GRADE=very low certainty • Narrative synthesis: primary studies reported only one (25%) of four significant favourable differences • No other meta-analysis available
	Other	• Narrative synthesis: primary studies reported only two (22%) of nine significant favourable differences • No other meta-analysis or narrative synthesis available

evidence underscores the need to consider changes in physical activity and sedentary behaviour together, rather than in isolation, as increased MVPA has been shown to mitigate risks of mortality and non-communicable diseases associated with prolonged sedentary time.[13,69] This finding supports the development of dual guidelines that address their combined effects. Second, our analysis identified substantial overlap in intervention components, with many studies evaluating their effects on both behaviours. Together, these findings challenge the rationale for treating physical activity and sedentary behaviour as separate outcomes when synthesising such evidence.

Despite the considerable heterogeneity in the evidence, our methodology identified clear effect trends with moderate-to-high confidence. Sit-to-stand workstations can reduce sedentary time by 67–75 min daily when used alone and by up to 100 min when combined with psychosocial strategies, such as goal setting or counselling. More complex, multilevel interventions, however, do not necessarily yield larger effects, a finding consistent with recent meta-analyses.[70–72] Two intervention types showed the largest increases in step counts, averaging about 1000 additional steps daily: self-monitoring paired with psychosocial strategies, often employed in mobile health interventions; and self-monitoring combined with interpersonal strategies (eg, competition or peer comparison), with or without financial incentives, as seen in gamified interventions.[73–76] Previous meta-analyses beyond workplace settings further highlight the value of these approaches, reporting increases of 926 steps (95% CI 651–1201) for self-monitoring paired with psychosocial strategies[77] and 1610 steps (372–2847) for self-monitoring paired with interpersonal strategies.[78] Although variability in measurement tools warrants cautious interpretation of step count changes, these findings are encouraging, given the associated health benefits. For adults younger than 60 years, all-cause mortality risk decreases progressively with up to 8000–10 000 steps daily,[79] with a 1000-step increment linked to a 15% reduction.[80] Sedentary time has minimal influence on the dose–response relationship between daily steps and mortality risk and only marginally affects cardiovascular disease risk.[81] These findings, alongside evidence that MVPA mitigates the harms of sedentary behaviour,[13,69] support prioritising interventions that replace sedentary time with physical activity, even lighter forms (appendix p 7), over those aimed solely at reducing sedentary time.

Our results highlight the need for more effective strategies to promote MVPA, as no specific intervention component has consistently shown improvements. Conditional financial incentives informed by behavioural insights might hold promise in this regard. For example, a recent megastudy of 53 strategies to encourage gym attendance found substantial benefits from approaches such as offering bonuses for returning after missed workouts or leveraging social norms.[82] Similarly, a large-scale workplace experiment showed that combining incentives with a commitment device—whereby individuals forfeit money if goals are unmet—improved gym attendance with lasting effects.[83] Although these findings are encouraging, there remains little understanding of how to effectively replace sedentary time with MVPA in workplace settings, where multiple barriers to engaging in more intense physical activity exist.

We acknowledge several limitations in our study. First, umbrella reviews are inherently constrained by the limitations of the systematic reviews they include. In our case, most reviews were rated as low or critically low in confidence using AMSTAR-2, a common finding in similar umbrella reviews.[72,84] Data extraction showed fragmented insights due to heterogeneity in review objectives, inconsistent intervention definitions and categorisations, and insufficient meta-analytical data. These issues hindered meaningful effect comparisons and clear policy recommendations. Although umbrella review guidelines generally discourage reanalysing primary data,[22] no consensus exists on how to synthesise such fragmented evidence when systematic reviews fail to pool data effectively to address the umbrella review objectives. Some authors suggest re-extracting data from primary studies or reanalysing them in a different way to that presented in the included systematic reviews.[85] This absence of standardised methodology presents a substantial challenge for umbrella reviews. Our dual-level synthesis approach, combining review-level and primary-level data, offered a more nuanced and comprehensive understanding, enhancing the reliability of our conclusions. However, systematic methods for integrating such dual-level findings are needed.

Second, our meta-analyses were not part of our a priori protocol, introducing potential limitations, particularly the risk of data-driven biases such as selective reporting. To address this risk, we applied rigorous eligibility criteria based on the number of extracted combinations of outcomes and intervention types, as well as study quality, focusing on objectively measured outcomes. These measures, along with the use of the GRADE approach, are key strengths of our study. However, the post-hoc nature of these analyses warrants caution in interpreting the findings. Further limitations stem from the evidence itself. Many primary studies had small sample sizes (ranging from 14 to 1084 participants, with 60% involving fewer than 100), particularly for environmental-level interventions, leading to imprecise effect estimates. Nevertheless, sensitivity analyses excluding small-sample studies showed results that were largely consistent with the primary analyses, with only small-to-moderate reductions in effect sizes.

Third, our subgroup analyses might have been influenced by the subjective nature of categorising intervention components. Our aim in categorising the intervention components was to strike a balance—making the categories specific enough to yield meaningful policy recommendations, while keeping them broad enough to ensure feasibility in conducting meta-analyses. Some interventions were difficult to classify, and alternative categorisations might be argued. Additionally, we focused solely on post-intervention effects. Ideally, both post-intervention and follow-up effects should be examined to assess long-term behaviour change. However, the volume and heterogeneity of the literature on post-intervention effects made follow-up effects beyond the scope of this study. Future research should synthesise follow-up effects as the evidence base expands in duration and quality, enabling policy makers and employers to identify cost-effective strategies for fostering habit formation and sustained behaviour change. Our findings are also limited to working adults without specific health conditions or mobility impairments (which represents roughly 87–88% of the working-age population in Europe[86]). To ensure broader applicability, promising strategies should be tailored and evaluated for populations with work-limiting health conditions. Finally, we were unable to assess differential intervention effects by socio-demographic characteristics, such as sex or ethnicity, due to the scarcity of subgroup analyses reporting these effects.

Providing policy makers with robust evidence on effective interventions to change movement behaviour habits is essential, as the global proportion of insufficiently active individuals continues to rise,[4] disproportionately affecting socioeconomically disadvantaged regions and populations.[87] Although our study showed the effectiveness of certain strategies, it also revealed a substantial evidence gap in low-income and middle-income countries, where physical inactivity[4] and non-communicable diseases[88] are increasingly prevalent. Bridging this gap calls for carefully designed megastudies[82] in under-represented regions, prioritising robust evidence generation over the fragmentation caused by numerous smaller studies, as well as minimising the high risk of bias present in existing research. Research involving disadvantaged workers should adopt the framework of necessity-based versus choice-based physical activity models to ensure equity and contextual relevance.[89] This approach entails developing policies that improve conditions for necessity-driven physical activity rather than promoting occupational physical activity that might be harmful (the physical activity paradox).[90] Similarly, workers engaged in strenuous physical labour are more likely to benefit from rehabilitative activities than from those aimed at increasing energy expenditure. Translating our findings into practice, therefore, requires careful consideration of local contexts, including working modes, workplace culture, environmental conditions, existing programmes, and technological capacities. Finally, the evolving nature of work arrangements and demands, largely influenced by the COVID-19 pandemic, could prompt researchers to explore accompanying changes in ecological determinants and movement behaviours.[91] Emerging evidence links work-from-home environments to increased sedentary behaviour,[92] highlighting the need for tailored strategies to prevent further exacerbation of the health burden associated with physical inactivity.

In conclusion, this study provides a comprehensive evidence synthesis on workplace interventions targeting sedentary behaviour and physical activity. Although we identified strategies that effectively reduce sedentary behaviour and promote lighter forms of physical activity—both of which are linked to measurable health benefits—none consistently improved MVPA, which delivers the greatest health benefits. With many countries falling short of the WHO target to reduce physical inactivity prevalence by 15% from 2010 levels by 2030,[4] addressing this gap is important for reaching global goals and reducing the health burden of physical inactivity.

Contributors

TR and AMM conceived and designed the study. EY and AVD conducted the literature search. EY, KA, AVD, SK, and SVD screened studies for eligibility and extracted the data. TR did the analyses with support from EY and drafted the manuscript. All authors contributed to the interpretation of the findings, provided subsequent edits to the manuscript, and approved the final version. AMM provided overall supervision for the project. TR, EY, and AMM had full access to and verified all the data in the study. All authors had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

Data are available from the corresponding author on request.

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