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SYSTEMATIC REVIEW

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Comparison of physical activity and sedentary behavior between telework and office work in a working population during the COVID-19 pandemic: a systematic review and meta-analysis of observational studies

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Abstract

Background The surge in telework due to technological advances and confinement during the coronavirus disease pandemic of 2019 (COVID-19) has drawn attention to its effects on physical activity (PA) and sedentary behavior (SB). This review aimed to analyze the impact of telework compared to office work in PA and SB, assessed by validated questionnaires and accelerometers during the COVID-19 pandemic.

Methods Observational studies that evaluated the effect of telework in PA and SB compared to office work were identified by literature searches in three electronic databases (PubMed, Web of Science, and Scopus) published up to January 2023. Studies were included when written in English, including observational design, evaluating the effect of telework on PA and/or SB compared to office work, and using validated questionnaires and accelerometers to assess PA and/or SB. The meta-analysis evaluated continuous outcomes with a random-effect model using Review Manager Web 5 (Cochrane Collaboration, Oxford, UK). The risk of bias was assessed using the National Heart, Lung, and Blood Institute quality assessment tool for Observational studies.

Results Twelve observational studies, with a total of 9,059 participants, were included in this study. Ten studies assessed PA and SB with questionnaires and two with accelerometers. A significant decrease of -0.33 (95% CI -0.59, -0.08) in light PA was observed, while no significant changes were observed for total PA (-0.19 [-0.42, 0.04]), moderate to vigorous PA (-0.44 [-1.32, 0.44]) and SB (0.12 [-0.20, 0.44]).

Conclusions Telework significantly decreases light PA in a working population during the COVID-19 pandemic. More research using validated measurement tools to assess PA and SB is needed to confirm this result. Given the extensive health benefits of physical activity and reduced sedentary behavior, public health resources must focus on encouraging PA and minimizing SB, especially among teleworkers.

Trail registration The review protocol was registered in the Prospero database (CRD42024502374).

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Keywords Telework, Remote work, Office work, Office setting, Physical activity, Sedentary behavior, Physical health

Background

Technological advances for remote working in the 21st century have caused a major shift in work modalities, with teleworking emerging as a prominent alternative to traditional office work. Teleworking is defined as working outside a traditional office setting or physical working environment, such as home or another location, using telecommunications technology to perform work tasks [1]. Alternatively, office work is defined as performing job-related tasks in a conventional office environment where employees are physically present at a central workplace [1]. It is well known that teleworking is more prevalent among administrative employees and managers [2]. This trend has gradually increased over the years and received an unprecedented boost during the confinement following the global COVID-19 pandemic [2, 3]. To contain the spread of the SARS-CoV-2 virus, governments worldwide implemented a wide range of regulations. These measures resulted in extensive restrictions on people's daily lives, including limitations on individual mobility [4, 5]. As a result of mobility limitations, most organizations were forced to adapt their traditional ways of working to remain productive. This led to a shift from office work to telework environments for a significant portion of the working population [2, 6]. Estimates suggest that, during the COVID-19 pandemic, teleworking increased from 9% to about 40% of the working population in the European Union following the governmental restrictions [7]. After the COVID-19 pandemic, in 2022, the amount of people doing telework for at least one day per week decreased to 33% [7].

The increase in teleworking presents opportunities and challenges regarding physical activity (PA) and sedentary behavior (SB). PA is defined as any bodily movement produced by the skeletal muscles that requires an energy expenditure above 1.6 metabolic equivalents (METs). In contrast, SB is defined as any waking behavior with an energy expenditure between 1.0 and 1.5 METs while sitting, reclining, or lying [7].

Working from home or a location away from the traditional office offers more flexibility, allowing employees to incorporate various activities into their daily routines [8, 9]. This flexibility could effectively address a significant barrier to behavior change faced by much of the working population: finding time for health-enhancing physical activity [10, 11]. While this transition to teleworking may be beneficial in many ways, it is also essential to identify any health risks for employees, especially regarding PA and SB.

The role of regular PA and minimizing SB are paramount to both individual well-being and public health. These lifestyle factors are critical components in the global strategy to combat the increasing prevalence of chronic diseases such as obesity, cardiovascular disease, and certain cancers [12–15].

Existing literature on the topic of telework and its effect on PA and SB often employs a mix of both qualitative and quantitative studies using non-validated measurement tools like self-developed questionnaires, to assess outcomes of PA and SB [16]. Although the combination of qualitative and non-validated quantitative studies provides strong evidence by synthesizing diverse data sources, the possible inconsistencies across studies and lack of generalizability due to subjective measures might affect the overall quality and outcomes of these studies. To address these challenges, Furuya et al. (2022) expressed the need for more research on the impact of telework on physical activity and health using validated measurement instruments to ensure reliability and comparability across studies [17]. This aligns with a study by Mokkink et al. (2010), where they highlight inconsistencies in measurement approaches and emphasize the need for validated measurement tools to ensure accurate and reliable results [18]. Existing reviews exploring the effect of telework on PA and SB during COVID-19 provide valuable insights but suffer from methodological variability [17–19]. To advance the field, the present study conducts a systematic review and meta-analysis of studies that specifically examine the impact of telework on PA and SB, compared to office work, during the COVID-19 pandemic using validated measurement tools to assess PA and SB. Additionally, this systematic review and meta-analysis focused on the general working-age population, excluding individuals with health issues that may influence the effect of telework on PA and SB [19].

Methods

This review was executed according to the preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) [20]. PRISMA consists of a 27-item checklist and flow diagram divided into four phases. The checklist contains items deemed essential for transparent reporting of a systematic review. The review protocol was registered in PROSPERO (CRD42024502374).

Search strategy and inclusion criteria

The following electronic databases were searched for studies published from January 2020 to 10 January 2024: "PubMed," "Scopus," and "Web of Science." Keywords used in the search were based on the PICO framework: P (Population): Employees, Working adults; E (Exposure): Telework, Remote working; C (Comparison): Traditional office work, no telework; O (Outcome): Physical activity, Sedentary behavior. Additionally, the reference lists of the included studies were screened for potentially relevant publications. A detailed overview of the search terms and Boolean operators used per database can be found in Table 1.

To be considered for inclusion, a study had to meet the following criteria: English language, observational study designs, evaluating the effect of telework on PA and/or SB in working adults, and using validated questionnaires or accelerometers to assess PA and/or SB. A questionnaire was recognized as validated when the results have been compared with objective measurements of PA, such as doubly labeled water or accelerometers. A validated questionnaire must demonstrate high reliability and accuracy in capturing real-life physical activity levels. Accelerometers are highly accurate compared to questionnaires and show a high reliability and validity. By only including studies in this meta-analysis that use validated measurement tools, we reduce the risk of measurement errors and enable comparison between the different studies.

Two reviewers independently screened all the titles and abstracts that potentially met the inclusion criteria. During the literature search, disagreements between the two reviewers (MP and PM) were discussed and resolved by consensus [21].

Data extraction and risk of bias assessment

Two reviewers independently carried out data extraction and risk of bias assessment. Any disagreements in data extraction and risk of bias assessment were discussed and resolved by consensus between two reviewers (MP and PM). The following data were extracted: First author, publication year, study characteristics (design, period, assessment methods, sample size), population characteristics (location, age, gender, occupation), PA, and SB outcomes. An overview of the included studies can be found in supplementary Table 1. The quality of the included studies was assessed using the 2013 National Heart, Lung, and Blood Institute (NHLBI) quality assessment tool for Observational Cohort and Cross-Sectional Studies [22]. A study was classified as "good" if there were "yes" answers to 70% or greater for the tool's criteria. A study was classified as "fair" if there were "yes" answers to 50–70% of the tool's criteria. And lastly, a study was classified as "poor" if there were "yes" answers to less than 50% of the tool's criteria [22].

Data synthesis

Due to the diversity of the study outcomes, different definitions of PA were standardized into three distinct categories: Total PA, Light PA, and Moderate to Vigorous Physical Activity (MVPA). Light PA includes all activities requiring low effort ranging between 1.6 and 2.9 METs, including walking, commuting, light housework, and standing activities such as food preparation or slow gardening. MVPA includes all activities requiring a moderate to high energy expenditure and falls within the range of 3 or more METs, including swimming, cycling, brisk walking, and running [10, 15]. SB includes all waking behaviors characterized by a low energy expenditure (between 1.0 and 1.5 METs), including sitting, long commuting while sitting, and screen time activities [16].

Quantitative analyses were performed with Review Manager Web 5 (RevMan 5: Cochrane Collaboration, Oxford, UK). Continuous outcomes and standard deviations (SD) were extracted for the studies included in this systematic review and meta-analysis. A random effect model, which accounts for between-study variability, was used to analyze the results. The primary measures considered in all meta-analyses were 95% confidence

Table 1 Search strategy

Database	Search Terms
PubMed	(("Office work"[Title/Abstract] OR "employees"[Title/Abstract] OR "working adults"[Title/Abstract] OR "workplace"[Title/Abstract] OR "worksite"[Title/Abstract] OR "job"[Title/Abstract] OR "occupation"[Title/Abstract] OR " teleworking"[Title/Abstract] OR "telework"[Title/Abstract] OR "flexible workplaces"[Title/Abstract] OR "home office"[Title/Abstract]) AND ("Physical Activity"[Title/Abstract] OR "exercise"[Title/Abstract] OR "Activity lifestyle"[Title/Abstract] OR "sports"[Title/Abstract] OR "movement"[Title/Abstract] OR " locomotion"[Title/Abstract] OR "Physical inactivity"[Title/Abstract] OR "Sedentary"[Title/Abstract] OR "Sedentary behavior"[Title/Abstract] OR "Sedentary time"[Title/Abstract] OR "sitting"[Title/Abstract] OR "sitting time"[Title/Abstract] OR "screen time"[Title/Abstract]))
Scopus	Title, abstract and keyword (("Office work" OR "employees" OR "working adults" OR "workplace" OR "worksite" OR "job" OR "occupation" OR " teleworking" OR "telework" OR "flexible workplaces" OR "home office") AND ("Physical Activity" OR "exercise" OR "Activity lifestyle" OR "sports" OR "movement" OR " locomotion" OR "Physical inactivity" OR "Sedentary" OR "Sedentary behavior" OR "Sedentary time" OR "sitting" OR "sitting time" OR "screen time"))
Web of Science	Title, abstract and keyword (("Office work" OR "employees" OR "working adults" OR "workplace" OR "worksite" OR "job" OR "occupation" OR " teleworking" OR "telework" OR "flexible workplaces" OR "home office") AND ("Physical Activity" OR "exercise" OR "Activity lifestyle" OR "sports" OR "movement" OR " locomotion" OR "Physical inactivity" OR "Sedentary" OR "Sedentary behavior" OR "Sedentary time" OR "sitting" OR "sitting time" OR "screen time"))

intervals (CI) and included Total PA, Light PA, MVPA, and SB. Heterogeneity was assessed using *p*-value and I^2 statistic, where a *p*-value below 0.05 meant significant heterogeneity, and an I^2 greater than 75% was considered high. As international peer-reviewed journals are more likely to publish statistically significant results, this may cause publication bias. In this meta-analysis, publication bias will be investigated by visual inspection of a funnel plot.

Results

Characteristics of included studies

The search methodology is illustrated in a flow diagram (Fig. 1). Initial PubMed, Scopus, and Web of Science searches yielded 902 articles. After 76 duplicates were removed, 799 articles were excluded after title or abstract screening. Next, 27 articles were reviewed in full text. In total, 12 articles met the inclusion criteria for this review [23–34]. Eight studies were cross-sectional studies, and four were cohort studies. The studies were conducted in several continents: Europe ($n=5$), North America ($n=3$), South America ($n=2$), and Asia ($n=2$). The data collection of all studies took place during the global COVID-19 pandemic when restrictions were in place. A total of 9,059 participants were included, and the mean ages of the participants ranged from 33 to 55.

The majority of the included studies used questionnaires ($n=10$) like the International Physical Activity Questionnaire (IPAQ), Work-related Physical Activity Questionnaire (WPAQ), Global Physical Activity Questionnaire (GPAQ), Paffenbarger Physical Activity Questionnaire (PAQ), or the Baecke Physical Activity Questionnaire (BPAQ). Although all of these questionnaires aim to assess PA via self-reporting, there are apparent differences in the recall period, activity domains, and measurement units used by the different questionnaires. The IPAQ and GPAQ are questionnaires based on a short recall period, while the BPAQ and Paffenbarger PAQ are based on a long recall period. Questionnaires like IPAQ and GPAQ assess multiple activity domains (work, transport, leisure time) and provide a comprehensive view of total PA. Additionally, with the BPAQ, WPAQ, and Paffenbarger PAQ, also domain-specific questionnaires (habitual, workplace PA or leisure-time PA) are included. Lastly, using different measurement units across the studies and questionnaires are used (min/day, min/week, h/day, MET/min/week, Baecke index).

Two studies used an accelerometer to assess PA and SB [30, 34]. Both the study of Hallman et al. (2021) and the study by Widar et al. (2021) used an Axivity AX3 triaxial accelerometer. In both studies, the accelerometer was placed on the front of the right thigh, midway between the hip and the knee joint. Whereas Hallman et al. (2021) collected data on PA and SB for seven constructive days, the study by Widar et al. (2021) collected data related to SB for five constructive days. Finally, both studies used Acti4 software to analyze the accelerometer data. A random-effect model is used to analyze the included studies to provide a realistic estimate of the overall effect.

Risk of bias within the studies

For the 12 included studies, the average score for the risk of bias was 8.5, which can be considered "fair." Four papers were categorized as "good" [28, 31, 32, 34], while the other eight papers were categorized as "fair" [23–27, 29, 30, 33]. None of the included studies were classified as "poor". Justification of sample size, assessment of repeated exposure, blinding of outcome assessors, and accounting for confounding variables were the criteria most often not met, which is consistent with the characteristics of cross-sectional research (Table 2).

Physical activity

In total, nine studies examined the association between telework and PA, of which two studies used an accelerometer to measure changes in PA [30, 34]. Changes in PA were reported with time indications (min/day, min/week, h/day, MET/min/week) except for one study that expressed the results in Baecke physical activity index, which is a numerical score that reflects the level of physical activity of the participants [25]. Due to missing data (mean and SD), two studies were not included in the quantitative analysis [26, 32].

Total physical activity

Data from four studies, including 2,191 participants, were meta-analyzed for total PA. All studies except one reported an overall decrease in total PA when participants engaged in teleworking. This result was not statistically significant ($p=0.11$).

The random-effect pooled standardized mean difference (Hedges' *g*) was −0.19 (-0.42, 0.04), and a high heterogeneity was observed ($I^2=88\%$) (Fig. 2). The most significant decrease in total PA was observed by Lipert et al. (2021), with a standardized mean difference (SMD) of -0.45 (-0.58, -0.32) [33].

Light physical activity

A total of four studies explored light PA and observed a decrease in light PA when participants engaged in teleworking compared to working from the office (Fig. 3) [23, 27, 30, 33]. The random-effect pooled SMD (Hedges' *g*) was −0.33 (-0.59, -0.08), which was statistically significant ($p=0.01$) (Fig. 3). Fukushima et al. showed the most significant decrease in light PA (SMD = -0.62 (-0.74, -0.51)) [27]. A high heterogeneity was observed between the studies ($I^2=84\%$).

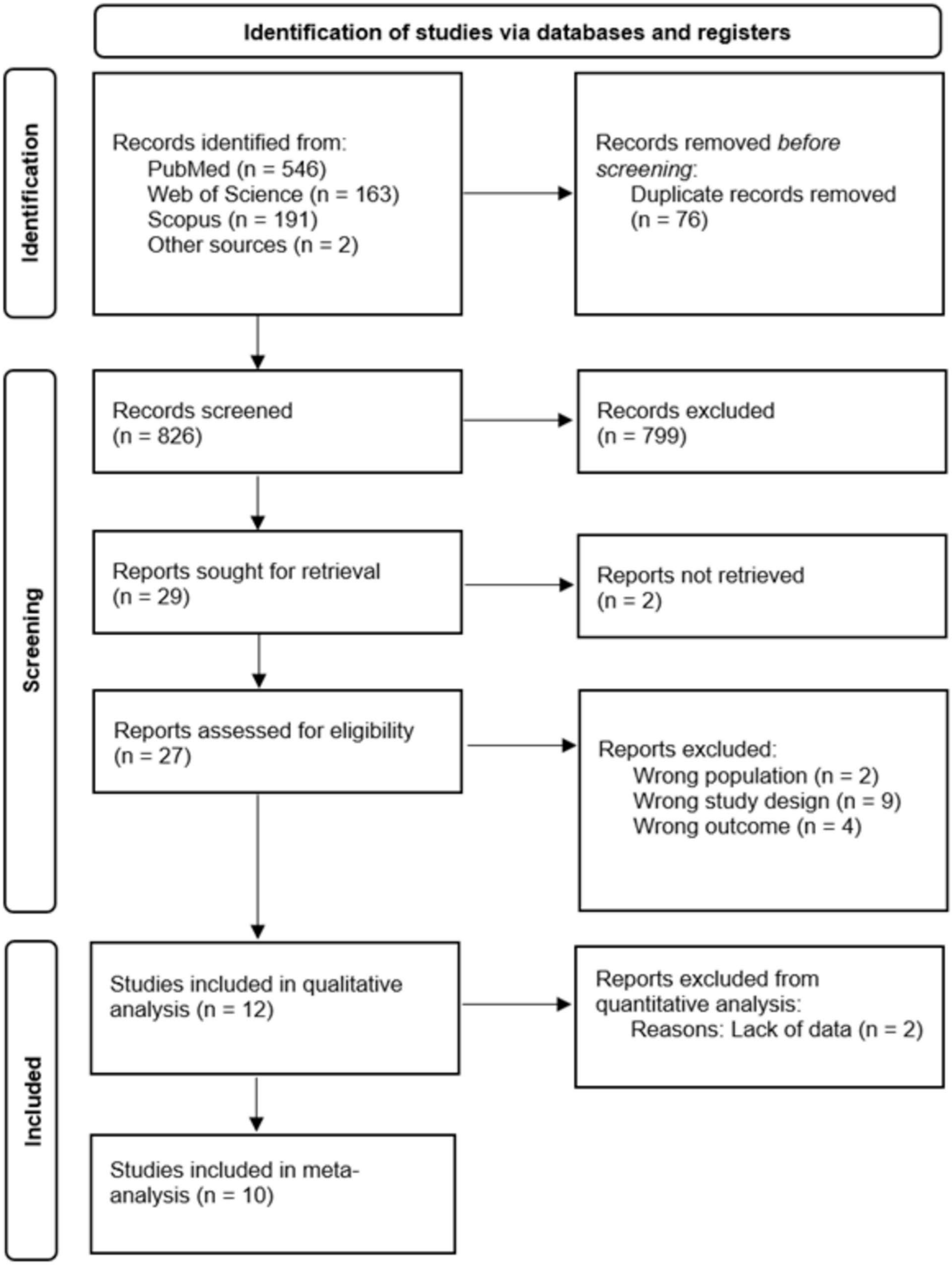

Fig. 1 Flow diagram of the study selection process

Table 2 Risk of bias analysis

	1. Research question or objective stated?	2. Study population specified and defined?	3. Participation rate of eligible persons at least 50%?	4. Were inclusion and exclusion criteria prespecified?	5. Sample size tested, power, and effect estimates provided?	6. Exposure of interest measured prior to the outcome?	7. Timeframe sufficient to see possible association?	8. Did the study examine different levels of exposure?	9. Exposure measures clearly defined across study participants?	10. Exposure assessed more than once over time?	11. Where outcome measures clearly defined?	12. Outcome assessors blinded to exposure status?	13. Was loss of follow-up after baseline < 20%?	14. Confounding variables measured and adjusted statistically?	Total Score
Aegerter at al. (2021) [23]	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	CD	CD	N	9
Aladro-Gonzalvo et al. (2021) [24]	Y	Y	N	Y	N	Y	Y	N	Y	N	Y	CD	CD	N	7
Argus et al. (2021) [25]	Y	Y	Y	Y	N	Y	Y	N	Y	N	Y	CD	CD	N	8
De Oliveira Da Silva Scarani et al. (2023) [26]	Y	Y	Y	Y	N	N	Y	Y	Y	N	Y	CD	CD	N	8
Fukushima et al. (2021) [27]	Y	N	Y	Y	N	N	Y	N	Y	Y	Y	CD	CD	N	7
Gibbs et al. (2021) [28]	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	CD	Y	N	10
Howe et al. (2021) [29]	Y	Y	Y	Y	N	Y	Y	N	Y	N	Y	CD	CD	N	8
Hallman et al. (2021) [30]	Y	Y	Y	Y	N	N	Y	N	Y	N	Y	CD	CD	N	7
Koohsari et al. (2021) [31]	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	CD	Y	Y	11
Limbers et al. (2020) [32]	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	CD	CD	Y	10

Table 2 (continued)

	1. Research question or objective stated?	2. Study population specified and defined?	3. Participation rate of eligible persons at least 50%?	4. Were inclusion and exclusion criteria prespecified?	5. Sample size tested, power, and effect estimates provided?	6. Exposure of interest measured prior to the outcome?	7. Timeframe sufficient to see possible association?	8. Did the study examine different levels of exposure?	9. Exposure measures clearly defined across study participants?	10. Exposure assessed more than once over time?	11. Where outcome measures clearly defined?	12. Outcome assessors blinded to exposure status?	13. Was loss of follow-up after baseline < 20%?	14. Confounding variables measured and adjusted statistically?	Total Score
Lipert et al. (2021) [33]	Y	N	Y	Y	N	Y	Y	Y	Y	N	Y	CD	CD	N	8
Widar et al. (2021) [34]	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	CD	Y	N	10

Legend: Y = yes; N = no; CD = cannot determine

Moderate to vigorous physical activity

For MVPA, seven studies evaluated possible changes due to teleworking. The majority of the studies reported a decrease in MVPA [27, 29, 31, 32]. With a random-effect pooled SMD (Hedges' *g*) of -0.44 (-1.32, 0.44). No statistical difference was observed ($p = 0.33$) (Fig. 4). Howe et al. reported the highest decrease in MVPA with a SMD of -2.71 (-2.82, -2.60) [29].

Sedentary behavior

A total of six studies examined the effect of telework in SB, of which two studies [30, 34] used an accelerometer to measure changes in SB. The remaining four studies used questionnaires. SB was expressed in minutes, min/day, or h/day. The analysis included a total of 2,060 participants and showed a high heterogeneity ($p < 0.05$, $I^2 = 93\%$). Consequently, a random-effect model was employed. The resulting pooled SMD (Hedges' *g*) was 0.12 (-0.20, 0.44), which was not statistically significant ($p = 0.46$). Although not statistically significant, the two studies using an accelerometer showed increased SB while engaging in office work [30, 34], while the studies using questionnaires showed mixed results (Fig. 5).

Publication bias

To assess publication bias, Review Manager Web was used to analyze sedentary behavior, as this included 6 of the 12 studies. With visual inspection, there seems to be asymmetry, which might indicate a high risk of publication bias, wherein small studies suggesting a decrease in sedentary behavior are published less (Fig. 6).

Discussion

This systematic review and meta-analysis aimed to investigate the changes in PA and SB caused by telework compared to office work during the COVID-19 pandemic. The majority of the twelve included studies were cross-sectional studies, showing a decreasing trend in PA. However, a significant decrease was observed only for light PA. No significant changes were observed for total PA, MVPA, and SB. Although no statistically significant results were found for total PA ($p = 0.11$), the low *p*-value indicates a trend suggesting that more telework is associated with lower total PA. Also in the case of SB a trend was found ($p = 0.12$), suggesting an increased SB while engaging in telework. The presence of high heterogeneity and possible publication bias complicated the interpretation of the results.

When examining the results of MVPA, Howe et al. (2021) reported a higher decrease in MVPA compared to the other studies included in the analysis [29]. As this questionnaire was conducted at the beginning of the COVID-19 pandemic, this might explain the larger reduction in MVPA due to the unforeseen closure of

Study or Subgroup	Telework Mean	Telework SD	Telework Total	No/Limited Telework Mean	No/Limited Telework SD	No/Limited Telework Total	Weight	Std. mean difference IV, Random, 95% CI
Aegerter (2021) (MET min/wk)	2370	2150	76	2150	2310	76	19.3%	0.10 [-0.22 , 0.42]
Argus (2021) (BPAI)	7.54	1.55	161	7.95	1.6	161	23.8%	-0.26 [-0.48 , -0.04]
Koohsari (2021) (h/day)	1.55	2.31	1315	1.75	2.79	1315	29.4%	-0.08 [-0.15 , -0.00]
Lipert (2021) (min/day)	121	124	639	185	171	344	27.6%	-0.45 [-0.58 , -0.32]
Total (95% CI)			**2191**			**1896**	**100.0%**	**-0.19 [-0.42 , 0.04]**

Heterogeneity: Tau² = 0.05; Chi² = 26.02, df = 3 (P < 0.00001); I² = 88%
Test for overall effect: Z = 1.61 (P = 0.11)

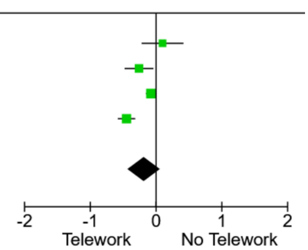

Fig. 2 Pooled effect size results of total physical activity

Study or Subgroup	Telework Mean	Telework SD	Telework Total	No Telework Mean	No Telework SD	No Telework Total	Weight	Std. mean difference IV, Random, 95% CI
Aegerter (2021) (MET min/wk)	981	890	76	1030	1030	76	22.4%	-0.05 [-0.37 , 0.27]
Fukushima (2021) (min/workday)	59.6	69.4	494	122.9	118.2	745	32.3%	-0.62 [-0.74 , -0.51]
Hallman (2021) (min/wk)	36	27	27	37	17	27	13.6%	-0.04 [-0.58 , 0.49]
Lipert (2021) (min/day)	27.9	32	639	39.9	35.6	344	31.7%	-0.36 [-0.49 , -0.23]
Total (95% CI)			**1236**			**1192**	**100.0%**	**-0.33 [-0.59 , -0.08]**

Heterogeneity: Tau² = 0.05; Chi² = 18.40, df = 3 (P = 0.0004); I² = 84%
Test for overall effect: Z = 2.58 (P = 0.01)

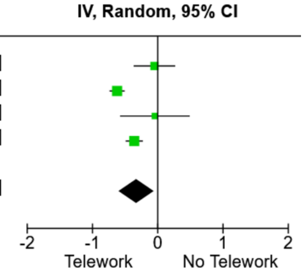

Fig. 3 Pooled effect size results of light physical activity

Study or Subgroup	Telework Mean	Telework SD	Telework Total	No Telework Mean	No Telework SD	No Telework Total	Weight	Std. mean difference IV, Random, 95% CI
Aegerter (2021) (MET min/wk)	929	1020	66	727	1160	60	14.1%	0.18 [-0.17 , 0.53]
Argus (2021) (BPAI)	2.42	1.18	161	2.94	1.31	161	14.3%	-0.42 [-0.64 , -0.20]
Fukushima (2021) (min/workday)	55.3	62.6	494	91.9	92.4	745	14.4%	-0.45 [-0.56 , -0.33]
Gibbs (2021) (h/day)	95	46.28	112	80	34.6	112	14.2%	0.37 [0.10 , 0.63]
Howe (2021) (min/wk)	243.3	13.4	1228	282.4	15.4	1228	14.4%	-2.71 [-2.82 , -2.60]
Koohsari (2021) (h/day)	0.33	0.72	1807	0.37	0.83	1315	14.4%	-0.05 [-0.12 , 0.02]
Lipert (2021) (min/day)	7.6	9.4	639	7.5	9.7	344	14.3%	0.01 [-0.12 , 0.14]
Total (95% CI)			**4507**			**3965**	**100.0%**	**-0.44 [-1.32 , 0.44]**

Heterogeneity: Tau² = 1.40; Chi² = 1814.11, df = 6 (P < 0.00001); I² = 100%
Test for overall effect: Z = 0.98 (P = 0.33)

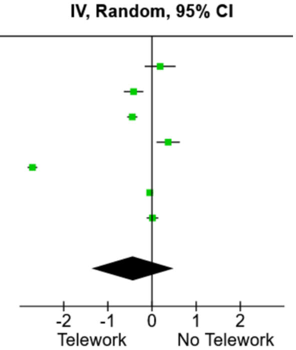

Fig. 4 Pooled effect size results regarding moderate to vigorous physical activity

Study or Subgroup	Telework Mean	Telework SD	Telework Total	No Telework Mean	No Telework SD	No Telework Total	Weight	Std. mean difference IV, Random, 95% CI
Aladro-Gonzalvo (2021) (h/day)	8	3.5	67	6.66	2.96	67	16.7%	0.41 [0.07 , 0.75]
Fukushima (2021) (min/workday)	336	153	494	225	174	745	20.2%	0.67 [0.55 , 0.79]
Gibbs (2021) (h/day)	11.3	4.3	112	10.9	3.8	112	18.1%	0.10 [-0.16 , 0.36]
Hallman (2021) (min/wk)	361	116	27	373	86	27	13.0%	-0.12 [-0.65 , 0.42]
Koohsari (2021) (h/day)	9.53	3.59	1086	8.96	3.53	1086	20.4%	0.16 [0.08 , 0.24]
Widar (2021) (h/day)	9.18	0.4	23	9.6	0.4	23	11.6%	-1.03 [-1.65 , -0.41]
Total (95% CI)			**1809**			**2060**	**100.0%**	**0.12 [-0.20 , 0.44]**

Heterogeneity: Tau² = 0.13; Chi² = 71.69, df = 5 (P < 0.00001); I² = 93%
Test for overall effect: Z = 0.74 (P = 0.46)

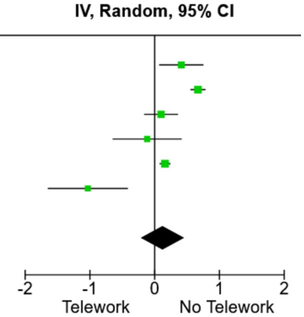

Fig. 5 Pooled effect size result of sedentary behavior

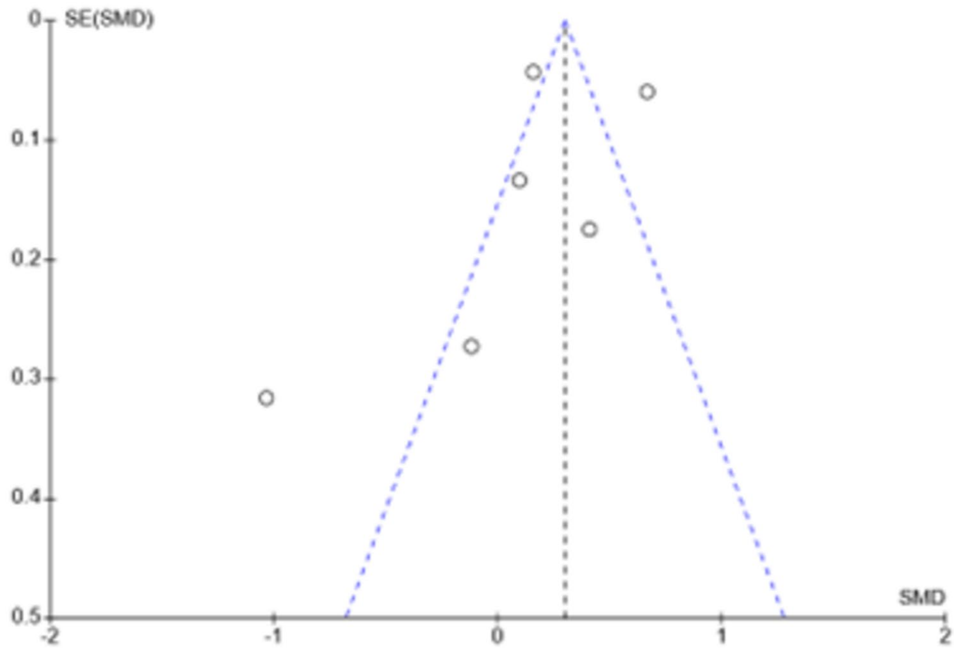

Fig. 6 Funnel plot publication bias

sports facilities [29]. Researchers investigated the relationship between SB and teleworking in six out of twelve studies. Of these, four showed an increase in SB when workers worked from home compared to office work [23, 28, 30, 34]. For workers who walk or bike to work, this increase in SB may be partly explained by the removal of commuting as a form of exercise. Fukushima et al. (2021) reported that the increase in SB was correlated with a decrease in light PA [27]. This increase in SB potentially poses some health risks. It is well established that SB is strongly associated with the development and progression of chronic diseases, including cardiovascular disease, diabetes, obesity, cancer, and arthritis [16].

Another finding of this review was the decrease in light PA but no change in moderate to vigorous and total PA. As different definitions of the dimensions of PA were used across studies, it was difficult to compare the results. However, when interpreting the results, most studies attributed the decrease in light PA to the lack of commuting, the nature of work at home, and fewer social interactions. Lipert et al. (2021) also attributes this to "parenting stress". In the studies of Kooshari et al. (2021) and Lipert et al. (2021), the slight decrease in light PA was accompanied by a reduction in total and moderate PA. Like an increase in SB, a decrease in PA can cause various health-related problems, such as obesity, cardiovascular disease, and cancers [15, 16]. Meyer et al. (2020) observed that reduced PA and increased screen time were associated with poorer overall well-being. Two studies reported no change in PA. The researchers speculated that a shift in working hours, caused by the elimination of commuting, was compensated by favorable climate conditions, causing people to spend more time on outdoor PA. This higher prevalence of spending time on outdoor PA compensates for eliminating PA due to the lack of commuting when working from home [23, 28].

In contrast to light PA, no significant change in MVPA was observed in this review. Although MVPA usually takes place in leisure time, Howe et al. (2021) reported that the closure of gyms, swimming pools, and other sports facilities could cause a decline in MVPA during the COVID-19 pandemic [29]. This aligns with a study by Argus et al. (2021), where researchers reported a decrease in PA in sports and leisure time before and during the COVID-19 pandemic [24].

When evaluating the results of the included studies, high heterogeneity is observed, which limits the meta-analysis' interpretability. The high heterogeneity observed across the included studies could be explained by using different measurement instruments and differences in reporting outcomes. In terms of measurement instruments, the included studies used accelerometers (Axivity AX3) and various questionnaires (BPAQ, GPAQ, IPAQ, WPAQ, GPAQ, Paffenbarger PAQ). Even though all instruments used in the included studies are validated, this use of both objective (accelerometers) and subjective (questionnaires) tools can cause heterogeneity [35]. Also, using different measurement tools creates differences in reporting outcomes (min/day, min/week, h/day, MET/min/week), making the pooling of data infeasible and creating heterogeneity. In addition, a high risk of publication bias was also observed for the studies evaluating SB, which may undermine the validity of the outcome on SB. However, it cannot be excluded that this risk of publication bias was influenced by the low number of included studies and the presence of high heterogeneity [36].

Strength and limitations

The strengths of this systematic review include the use of an established search protocol to ensure the objectivity of the evaluation method. The literature search and risk of bias analysis involved two reviewers who independently evaluated the literature and resolved disagreements. Furthermore, this study reports on MVPA instead of reporting on moderate and vigorous levels of PA individually. Research has shown that comparing PA levels obtained from questionnaires with those measured by accelerometers can be influenced by discrepancies between those two measurement tools. It is well known that self-reported methods can often lead to recall bias, social desirability, and difficulties in accurately categorizing activity intensities, mainly seen between moderate and vigorous PA [37, 38]. Aggregating moderate and vigorous PA into a single measure, MVPA, as we have done in this study, can mitigate some of these possible discrepancies and reduce misclassification errors inherent in self-reported data. By focusing on MVPA, researchers can achieve a more consistent and comparable assessment of PA levels across different measurement tools, enhancing the reliability of findings in PA research [39]. However, some limitations must also be addressed. Firstly, the search for this review was limited to three databases and did not include gray literature or studies published in languages other than English. Consequently, there may be relevant studies that are not included in this review. Additionally, the data collection for each study took place during the COVID-19 pandemic. Therefore, it is impossible to extrapolate these data to everyday life without pandemic limitations. The studies investigating telework with PA and SB outside the COVID-19 pandemic were mainly qualitative or did not use validated measurement instruments or questionnaires, meaning they were not included in this systematic review and meta-analysis [40–42]. Since most of the included studies are cross-sectional, causality between telework and PA and SB cannot be confirmed. Also, the heterogeneity and limited time frame of these studies limit the depth of our observations. Although all questionnaires included in this study aim to assess PA via self-reporting, there are apparent differences in the recall period, activity domains, and measurement units used by the different questionnaires, causing high heterogeneity between studies. These differences may influence the overall results of this study. Questionnaires with short recall periods (IPAQ, GPAQ) reduce recall bias but may not capture habitual PA, while questionnaires using long recall periods (BPAQ, Paffenbarger PAQ) increase the risk of recall bias. Questionnaires like IPAQ and GPAQ assess multiple activity domains (work, transport, leisure time) and provide a comprehensive view of total PA. The results of IPAQ and GPAQ might not be directly comparable with domain-specific questionnaires like BPAQ, WPAQ (habitual or workplace PA), and Paffenbarger PAQ (Leisure-time PA). Lastly, using different measurement units across the studies (min/day, min/week, h/day, MET/min/week, Baecke index) can impact comparability. By selecting the use of validated questionnaires, we can respond to these methodological discrepancies. We reduce the risk of measurement errors and enable comparison between the different studies. The possibility of publication bias must also be acknowledged. In addition, it also cannot be ruled out that the results we observed regarding the association of telework and PA and SB were highly influenced by the confinement due to the COVID-19 pandemic, including restrictions on individual mobility and the closure of gyms and sports clubs. However, despite these limitations, few studies have examined the association between telework and PA and SB independent of the COVID-19 pandemic.

Implication for practice

Despite the high heterogeneity between studies and the high risk of publication bias that may affect the interpretation of the results in this meta-analysis, it was identified that only light PA decreased in response to an increase in telecommuting. In practice, institutions or companies offering to telework should encourage physical activity by providing guidance on dealing with decreased physical activity, such as ways to engage in PA when employees telework or by providing gym memberships. Since PA plays a vital role in individual and public health, encouraging light PA during telework can be an opportunity for an institution/company to contribute to the health of employees in the occupational environment.

Conclusion

This review provided evidence regarding the impact of telework on physical activity and sedentary behavior compared to office work during the COVID-19 pandemic. To address possible methodological inconsistencies that previous studies on this subject have encountered, this study only included studies using validated measurement tools to evaluate PA and SB. Our findings indicate that telework significantly decreases light PA compared to office work in a working population during the COVID-19 pandemic. It can be speculated that this decrease in light physical activity is partly due to the restrictions imposed by governments to prevent the spread of COVID-19, which were in place during data collection in the included studies. To estimate the actual effect of telework on changes in physical activity and sedentary behavior and, therefore, public health, future research should focus on examining the impact of telework on physical activity and sedentary behavior in conditions without restrictions limiting individual mobility while using validated assessment tools.

Abbreviations

COVID-19	Coronavirus disease pandemic of 2019
PA	Physical activity
SB	Sedentary behavior
MET	Metabolic equivalent
PRISMA	Preferred reporting items for systematic review and meta-analyses
PICO	Population, intervention, comparison and outcomes
NHBLI	National heart, lung and blood institute
MVPA	Moderate to vigorious physical activity
CI	Confidence interval
IPAQ	International physical activity questionnaire
WPAQ	Work-related physical activity questionnaire
GPAQ	Global physical activity questionnaire
PAQ	Physical activity questionnaire
BPAQ	Baecke physical activity questionnaire
SD	Standard deviations
SMD	Standard mean difference

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22948-1.

Supplementary Material 1

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Not applicable.

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Competing interests
The authors declare no competing interests.

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